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ABSTRACT

This publication is intended to serve as a teacher's guide for the instructional television series entitled "What On Earth?" The program, a one-year course for eighth-grade students, is composed of units on the earth as a body in space, meteorology, oceanography, and geology. Each topic is covered through a series of television programs. In the guide, each lesson is described in terms of a synopsis, concepts, objectives, learning activities, and references. Textbook references for each major unit of study are provided. As additional material, the publication contains lists of equipment for the earth science classroom, a textbook bibliography and a directory of publishers and distributors. (CP)

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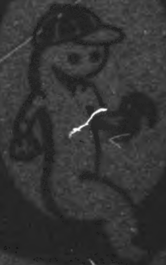
TEACHER'S GUIDE

What On Earth?



AN INSTRUCTIONAL TELEVISION SERIES FOR EIGHTH-GRADE EARTH SCIENCE

SE 025 261

What On Earth?

Teacher's Guide

We want students to learn to view the earth as their home planet and respond to its phenomena on a personal level. We can teach students the mechanics of weathering and the physics of a breaking wave, but we must also allow them to meet and sense the earth, in a personal way. If we can help them reach this goal, they will experience a thrill in every sunset and an exhilaration in every windy day or walk in the countryside that will add immeasurably to the quality of their lives and ours as well.

Fred L. Beyer
Curriculum Specialist
School Television
Division of Educational Media
Department of Public Instruction
Raleigh, North Carolina 27611

c 1978

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A Tip of the Hat

In any project such as the WHAT ON EARTH? series, dozens of people assist the production effort in many ways. There are many who volunteered their time and effort with little or no reward. Special thanks are due to Dorothy Zimmerman, Pauletta Parker, James Hooks, Rue Rush, John McLain, Dr. Ernie Knowles, Dr. Cyril Harvey, and Bill Wilson who served on the advisory committee and helped write the basic curriculum document on which the series is based. Later they offered advice and reviewed the early programs, proposing changes that greatly improved other programs. Within the State Department of Public Instruction, Reta Richardson and Dr. Paul Taylor helped unravel the day to day problems of finance and logistics that go with any project this size.

The production team of Curry Leslie, Jim Bramlett, and Charlie Huntley put in thousands of hours in rain, snow, and blowing sand to get the necessary film and then worked nights and weekends assembling the pieces into finished programs. Their talents, dedication, and creativity are largely responsible for the quality of the final product.

Dozens of other individuals from the National Park Service, National Weather Service, Duke Marine Laboratory, U. S. Geological Survey, Smithsonian Institution, and North Carolina Consolidated University System devoted time and effort to the production of individual segments.

A gigantic thank you is due to Mr. James Carruth who secured the administrative and financial support of the State Board of Education and helped to make the series possible through his continued support and encouragement. After his retirement, Mrs. Elsie Brumback continued supporting the effort as it moved toward its conclusion. Without their aid WHAT ON EARTH? simply would not exist.

Finally, to all the hundreds of people who helped with individual problems and to the teachers who spurred us on with their advice and encouragement--thank you. This series belongs to you and your students and would never have existed without your insistence on the best in support materials for students studying the earth.

An Introduction

History

The television series you are about to use was conceived in 1970 during the production of an inservice television course for teachers. The participating teachers had asked for visual tools to help students with earth science topics on local breezes, mapping, beach landforms, and folding. In many cases we were unable to find any usable material, and in most cases those materials that had been produced were inappropriate for use with middle school students. As a result, a proposal was submitted to the North Carolina State Board of Education for the production of a television series to be used by eighth-grade students studying earth science. The board gave its approval and work began in the spring of 1971 on the programs that were to become WHAT ON EARTH?

The first task was to establish a course of study that could be used as a scope and sequence for the television programs. An advisory committee consisting of an astronomer, a meteorologist, an oceanographer, two geologists, three teachers, an administrator and two television specialists met to help the curriculum specialist develop a list of concepts appropriate for eighth-grade students. A series of objectives and a teaching outline were written, and along with the concepts, were published as EARTH SCIENCE: A COURSE OF STUDY FOR WHAT ON EARTH?--A TELEVISION SERIES.

As the course of study was being printed, the entire program was studied to select topics for which television treatments would be most effective. Scripts were written and production of the first three programs began in October 1971. During the following September, the programs were broadcast on a trial basis. Fifty-three teachers helped evaluate those early efforts and their comments were used to revise the program format. In addition, the production team and members of the advisory committee evaluated students' responses. In subsequent years, teachers continued to offer suggestions and comments which influenced the development of the entire series. Three more programs were produced during the 1972-73 school year and in September 1973 the production team once again visited classrooms for a first-hand look at student reactions to all six programs.

During the 1973-74 school year, the production effort intensified. The film crew traveled to the National Oceanic and Atmospheric Administration's climatic and forecast centers, preparations were made for two of the three major location filming efforts, and much of the filming for the meteorology programs was completed. In May, the production team flew to Denver and began a six-week location shooting schedule that included scenes for all the geology programs and several shoreline programs.

Among the locations filmed, were the Rocky Mountain National Park, Chaco Canyon National Monument, the Grand Canyon, Yosemite National Park, and the California coast. Returning from the West, the production crew immediately joined the Duke University research vessel, EASTWARD, for a two-week cruise that resulted in most of the film you will see in Programs 15 and 16.

As the fall and winter of 1974-75 passed, work continued on the meteorology and oceanography programs. In December the crew spent one week filming behind the scenes in the Smithsonian Institution's Mineral Sciences Division. The resulting film included close-up looks at hundreds of minerals, high-lighted by the Hope

Diamond. By May, all of the meteorology programs, the oceanography and shoreline programs, and the geology program on minerals were completed.

In June of 1975, the second Western filming trip carried the cameras to Craters of the Moon National Monument, Hebgen Valley, the Beartooth Plateau, Yellowstone, the Black Hills and the Badlands. The trip, which included shooting under desert conditions and on snow eighteen feet deep, resulted in some of the most spectacular film in the series.

In the following eighteen months, the film which had been shot over the preceding three years was assembled along with footage from the National Park Service and other sources to produce the nine programs that comprise the geology series. In early August of 1977, the final touches were added and the WHAT ON EARTH? television series was complete.

Series Overview

WHAT ON EARTH? consists of twenty-nine programs composed of sixty-nine segments. These are divided into four units. The first unit of five programs considers the earth as a body in space covering topics such as seasons, location, gravity, time and map making. The meteorology unit, Programs 6-14, studies the structure of the atmosphere, weather forecasting, and climate. Oceanography and shore processes, the third unit, occupy Programs 15-19. The last unit of geology programs consider minerals, constructional and destructional forces, landforms, and geologic time.

Most programs run 20 to 30 minutes in length and are divided into segments of approximately 10 minutes each. Each segment covers a specific topic such as cloud formation, movement of sand on a beach, or water underground. Some segments, such as cyclonic storms, are purely instructional but the majority of segments combine instruction with aesthetic and occupational emphases. Several segments illustrate the work of people in the earth sciences: surveyors, cartographers, printers, cooks, navigators, geologists, miners, meteorologists, and computer operators. In every case, the individual in the program does the job he or she is shown carrying out.

Scattered throughout the series there are special segments that attempt to give students a unique view of their planet. A walk in the snow stresses the special nature of a snow-covered land for students who seldom experience such a phenomenon. Likewise, "Mountains Are the Wild Places of the Earth," "Waterfalls," and "Man vs. the Sea" attempt to awaken special feelings in students for the planet on which they live.

How to Use This Series

While a great deal of time and effort has been expended to produce the WHAT ON EARTH? television series, it should not be considered the principal element in any earth science course. The segments are not designed to stand alone. Instead they are intended to be only one part of your instructional design. The segmented design of the series allows you, as the teacher, to use a segment on videotape or film whenever and however it best meets your teaching needs. While the scope and sequence were carefully planned, they should be altered to meet the needs of your students and the conditions of your classroom setting.

You may wish to use a particular segment to introduce or review a topic. Some segments you may wish to show to the entire class, for other segments, a small group or even individual students may be a more appropriate audience. You may even feel that some topics are appropriate for one class but not for another.

I believe you will find this teacher's guide valuable in making decisions for using each program. The guide is divided by program and segment. A page at the beginning of the guide provides an overview, student text references, and a list of books that students might wish to read dealing with topics covered in the program. Each segment in the program is described on its own page. A segment synopsis, concepts, and objectives for each segment form the core of the guide. Suggestions for previewing activities and follow-up investigations are offered along with a list of available films, slides and other media. A special list of teacher references is also included to allow you to read in-depth on each topic if you so desire. Sets of slides are available for most segments. Each set includes scenes from particular segments so that you may repeat an explanation using the examples students have seen in the program.

The WHAT ON EARTH? series is now in your hands. I hope you will find it a valuable addition to the resources available for teaching students about the earth. As you prepare to use the programs, keep in mind that we want students to learn to view the earth as their home planet and respond to its phenomena on a personal level. We can teach students the mechanics of weathering and the physics of a breaking wave, but we must also allow them to meet and sense the earth in a personal way. If we can help them reach this goal, they will experience a thrill in every sunset and an exhilaration in every windy day or walk in the countryside that will add immeasurably to the quality of their lives and ours as well.

Unit 1

The Earth: A Body in Space

The early programs in the WHAT ON EARTH? television series introduces students to the planet earth. The first program presents scientists who study the earth, shows how the scientific method has worked to increase knowledge in one branch of the earth sciences and presents the environmental ethic upon which the entire series is based.

The second, third, and fourth programs shift the student's point of view to the planet as a body in space: its size, shape, motions, and the forces which act upon it as it moves through space. In Program 5, the student's focus returns to the study of the planet's surface, considering maps of all kinds but concentrating on those which describe the planet's surface, shape, and form.

Thus, the first five programs lay the ground work for the study of a dynamic and constantly changing planet. Students will then move on to studies of the atmosphere, hydrosphere, and lithosphere. In addition they acquire basic mapping skills that they use in later weeks to describe the atmosphere, oceans, and crust of the earth.

Reference

Strahler, Arthur N. 1971. THE EARTH SCIENCES. 2nd ed. New York: Harper and Row.

9

1

What On Earth?

What on Earth?
I Am a Part of Nature
Scientific Method

Program Overview

This opening program introduces students to the study of earth science and the WHAT ON EARTH? television series. The first segment defines earth science and describes its numerous scientific disciplines. The second segment, I AM A PART OF NATURE, suggests that the earth is man's home in space and that he has a responsibility to protect it from harm. The final segment suggests the scientific method as a way of approaching problems.

Textbook References

- A SEARCH FOR UNDERSTANDING
  Workshop Unit I, pp. 40-45
- MODERN EARTH SCIENCE
  No references
- PATTERNS IN OUR ENVIRONMENT
  Ch. 1: Patterns in Our Environment, pp. 1-18
  Ch. 2: Changes in Our Environment, pp. 20-49
- THE WORLD WE LIVE IN
  No references
- EARTH SCIENCE: A LABORATORY APPROACH
  No references
- EARTH SCIENCE: IIS
  Idea 1: Foundations: Matter, Energy, and Time, pp. 1-36
  Idea 2: The Solar System, pp. 39-52
- FOCUS ON EARTH SCIENCE
  No references
- HOLT: EARTH SCIENCE
  Starting Out, pp. 1-13
- INVESTIGATING THE EARTH
  No references
- OUR ENVIRONMENT IN SPACE
  Ch. 1: Interpretation, a Process of Science, pp. 11-23
- PATHWAYS IN SCIENCE
  No references

Student Reading

Calder, Nigel. *The Weather Machine*. New York: Viking Press, Inc., 1975.

WHAT ON EARTH ?

What On Earth?

Segment Synopsis

What does an earth scientist do? Why should I study earth science? These are questions asked at least once by all earth science students. This opening segment of the WHAT ON EARTH? television series attempts to answer these questions briefly. It describes the earth as man's home but also as a closed and limited system. Earth science is divided into four major branches; astronomy, meteorology, oceanography, and geology. Students meet a representative from each branch and preview some of the places they will visit through the WHAT ON EARTH? series.

Concept

- Earth science is a broad discipline which studies the earth and its surroundings.

Objective

After watching this program and completing appropriate follow-up activities, the student should be able to

- explain how the various branches of earth science study the earth.

Learning Activities

Have students look up and learn the meaning of the terms: geologist, oceanographer, meteorologist, climatologist, cartographer, astronomer.

Discuss the kinds of things earth scientists study. What is meant by the phrases "the space ship earth" and "the earth is a closed system"?

Ask students if they have been to any of the places the program will visit during the coming year. If some volunteer, ask them to prepare a story of their trip for the class and present it later in the year.

Conduct a cartoon contest with a prize for the best cartoon of a geologist, meteorologist, oceanographer and astronomer.

Invite an earth scientist to visit the class and explain his work and its relationship to other earth sciences.

Collect pictures for a display of earth scientists at work.

Challenge your students to construct a "tree of science" puzzle overnight.

Teacher References

Exline, Joseph D. 1975. *Individualized Techniques for Teaching Earth Science.* Englewood Cliffs, NJ: Prentice-Hall, Inc.

Oxenhorn, Joseph M. 1972. *Teaching Science to Underachievers in Secondary Schools.* New York: Globe Book Co., Inc.

Triezenberg, Henry J. 1972. *Individualized Science: Like - It - Is.* Washington, DC: National Science Teachers Association.

I AM A PART OF NATURE

I Am a Part of Nature

Segment Synopsis

I AM A PART OF NATURE is based on a poem by Henry Gibson. The segment is designed to show students the beauty of nature and the ugliness of some of mankind's activities. It leads students to develop their own environmental philosophy.

I am a part of nature.
I am a part of everything that lives.
I am bound together with all living things
in air, in land, in water,
Upon its balance, upon its resources,
and upon the continuity of both.
To destroy them is to destroy myself.
As a member of the human race
I am a part of nature.
I will not destroy it.

--Henry Gibson

Concepts

- Earth science is a broad discipline of sciences which study the earth and its surroundings.
- Some changes on our planet are influenced by man's presence.

Objective

After watching this program and completing appropriate follow-up activities, the student should be able to

- give some examples of ways in which mankind's presence has changed the earth.

Learning Activities

Ask students to suggest ways in which they are related to all living things. How do living things depend on man? How does man depend on them? How do their lives depend on nature's balance? On nature's resources?

Ask students for examples of ways in which they have protected or destroyed nature. What has man done to change his planet? Have the changes been good or bad? Can he predict the pattern of change? Ask how each student fits into these changes. Do they affect him now? later?

Discuss the earth as a limited system. How is it, why? Do changes occur at different rates? Where do changes occur?

Have students form small groups and draw up their own statements of environmental philosophy.

Take a field trip around the school grounds, look for examples of short and long term change. Use a camera to record examples of change.

Begin "earth watch" activities. Have students report weather, earthquakes, volcanic eruptions, and disasters to the class.

Teacher References

Leveson, David. 1972. *A Sense of the Earth*. Garden City, NY: Doubleday and Co., Inc.

CRM Books Editorial Staff. 1974. *Geology Today*. New York: Communications Research Machines, Inc.

1-3

SCIENTIFIC
METHOD

Scientific Method

Segment Synopsis

The structure and process of science are complex and nebulous areas which usually present some problems for students. This segment is designed to illustrate the idea that science develops not by spurts of genius, but by slow and arduous labor. Each concept that is developed, tested, and proven true, becomes the basis for future questioning and research. So a completed theory is constructed on a large foundation of hypotheses, theories, and laws that were discovered and proven by earlier investigators.

SCIENTIFIC METHOD looks at the discoveries leading to the development of the Fluid Dynamics Theory by Vilhelm Bjerknes in the early twentieth century. The story traces Greek observations and the work done by Galileo, Hooke, and Torricelli to develop instruments capable of measuring the properties of the atmosphere. It concludes with an account of Bjerknes' theory and asks students if they can suggest what the overall theme of the segment might be. This segment can be used to introduce or review the scientific method.

Concepts

- Man's mind is his most important tool for investigating the earth.
- Man's mind is used to interpret the observations he makes with his senses.
- Man uses instruments to extend his senses.
- Measurements are essential for quantifying observations.
- Earth changes are detectable by observation.
- Certain patterned changes are predictable.

Objectives

After watching this program and completing appropriate follow-up activities, the student should be able to

- give examples of ways in which his senses limit his investigation of the earth
- demonstrate a basic understanding of measurement
- identify change in terms of location and action
- predict certain simple patterns of change
- describe the earth as a "closed system."

Learning Activities

Have students prepare one paragraph biographies on Galileo, Hooke, Torricelli, and Vilhelm Bjerknes.

Introduce or review the following terms: thermometer, barometer, air pressure, fluid dynamics.

Have groups of students conduct library research for a bulletin board tracing the major discoveries in meteorology.

Have students observe a sunset and record their observations.

Have a group of students prepare a display showing the steps an hypothesis might follow to become a law.

Divide students in to groups and have them record their observations of a natural mud puddle.

Have students develop their own scale of measurement.

Fashion "boxes of mystery" and arrange them around the room.

Have students describe the materials contained in the boxes using various senses and instruments. Have them record their observations and compare their descriptions.

Have students prepare displays showing the sequence of events leading to scientific discoveries in meteorology.

Have students conduct investigations outlining each step of the scientific method they use.

Take a sample of earth material and change it in some way, listing and explaining each action.

List some event that changes through varying periods of time and space (shifting of sand, changing shoreline, bubbles, etc.). Try to develop scientifically valid designs for predicting the events.

Media Resource

FILMSTRIP

NEW METHODS OF FORECASTING WEATHER. 1 filmstrip, 1 cassette tape. Stone Productions, 1971.

Teacher References

Aristotle, 1952. *Meteorologica.* Cambridge, MA: Harvard Univ. Press.

Crombie, A. C. 1959. *Medieval and Early Modern Science.* 2 vols. Garden City, NY: Doubleday and Co., Inc.

Ross, Frank, Jr. 1964. *Weather: The Science of Meteorology from Ancient Times to Space-Age.* New York: Lothrop, Lee and Shepard Co.

Ruchlis, Hyman. 1963. *Discovering Scientific Method.* New York: Harper and Row.

Whitnah, Donald R. 1965. *A History of the United Weather Bureau.* Urbana, IL: Univ. of Illinois Press.

2

The Earth in Space

Man Looks to the Stars
A Chip Bobbing in the Ocean of Space
Foucault and His Pendulum
Microbes to Stars
The Seasons

Program Overview

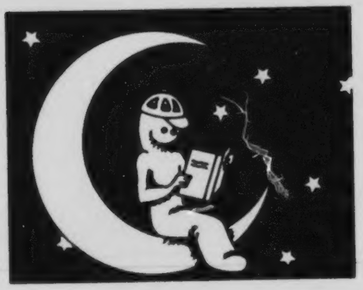
THE EARTH IN SPACE is the first of two programs studying the earth as a planet. Programs 2 and 3 focus on the planet's relationship to the solar system and are designed to change the student's view of his home in space. They explore the motions of the earth, man's developing view of the universe, and the size of the earth in relation to the natural world.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 1-1: The Earth from Space, pp. 4-7
  - Ch. 1-2: The Shape of the Earth, pp. 8-10
  - Ch. 17: Man's First Observatory-The Earth, pp. 550-573
- MODERN EARTH SCIENCE
  - Ch. 1: Design of the Universe, pp. 2-20
  - Ch. 2: The Sun, pp. 21-46
  - Ch. 3: The Earth as a Member of the Solar System, pp. 47-74
- PATTERNS IN OUR ENVIRONMENT
  - Ch. 3-12: People and Time, p. 63
  - Ch. 9-2 : The Nighttime Sky, pp. 255
  - Ch. 9-13: The Size of the Solar System, pp. 275
  - Ch. 9-16: The Size of the Universe in Six Steps, pp. 278-280
- THE WORLD WE LIVE IN
  - Ch. 26: Stars and Galaxies, pp. 374-402
  - Ch. 27: The Solar System, pp. 403-425
  - Ch. 28: Exploring Space, pp. 426-444
  - Ch. 29: Our Moon, pp. 445-465
  - Ch. 30: The Earth's Motion, pp. 466-475
- EARTH SCIENCE: A LABORATORY APPROACH
  - Ch. 11: The Earth in Space, pp. 245-273
- EARTH SCIENCE: IIS
  - Idea 2: The Solar System, pp. 53-76
- FOCUS ON THE EARTH
  - Ch. 22: The Solar System, pp. 444-469
- HOLT: EARTH SCIENCE
  - Ch. 13: The Earth in Space, pp. 370-401
  - Ch. 14: The Solar System, pp. 404-445
  - Ch. 15: The Universe, pp. 447-470
- INVESTIGATING THE EARTH
  - Ch. 1: The Earth and Moon in Space, pp. 3-22

- OUR ENVIRONMENT IN SPACE
  Ch. 4: Earth Science and Man's Environment, pp. 63-84
  Ch. 5: The Earth in Motion, pp. 87-110
  Ch. 7: The Energy Exchange, pp. 133-150

- PATHWAYS IN SCIENCE
  Unit 7: Man in His Universe, pp. 335-382



Student Readings

Allison, Linda. *The Reason for Seasons.* Boston: Little, Brown, and Co., 1975.

Asimov, Isaac. *How Did We Find out the Earth is Round?* New York: Walker and Co., 1972.

__________. *The Tragedy of the Moon.* Garden City, NY: Doubleday and Co., Inc., 1973.

__________. *Asimov on Astronomy.* Garden City, NY: Doubleday and Co., Inc., 1974.

Brown, Peter L. *Comets, Meteorites, and Men.* New York: Taplinger Publishing Corp., 1974.

Butler, S. T., and Robert Raymond. *The Family of the Sun.* Garden City, NY: Doubleday and Co., Inc., 1970.

Calder, Nigel. *The Violent Universe: An Eyewitness Account of the New Astronomy.* New York: Viking Press, Inc., 1970.

Coutright, Edgar M. *Exploring Space with a Camera.* Washington, DC: National Aeronautics and Space Administration, 1968.

Kals, William S. *How to Read the Night Sky.* Garden City, NJ: Doubleday and Co., Inc., 1974.

Limburg, Peter. *What's in the Names of Stars and Constellations.* New York: Coward, McCann, and Geoghegan, Inc., 1976.

Lyon, Jene. *Astronomy: Our Sun and its Neighbors.* New York: Western Publishing Co., Inc., 1974.

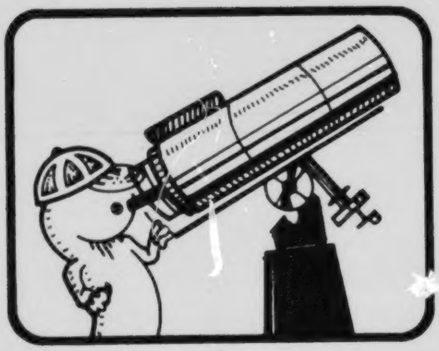
Moore, Patrick. *The Picture History of Astronomy.* rev. ed. New York: Gosset and Dunlap, Inc., 1972.

Muirden, James. *The Amateur Astronomer's Handbook.* rev. ed. New York: Thomas Y. Crowell Co., 1974.

Peltier, Leslie C. *Guideposts to the Stars: Exploring the Skies Through the Year.* New York: Macmillan Publishing Co., Inc., 1972.

Ravielli, Anthony. *The World is Round.* rev. ed. New York: Viking Press, Inc., 1970.

Spencer-Jones, Harold. *The New Space Encyclopaedia: A Guide to Astronomy and Space Exploration.* rev. ed. New York: E. P. Dutton and Co., Inc., 1974.



Man Looks to the Stars

Segment Synopsis

The idea that the earth is not the center of all things but is, in fact, only a minor inner planet circling around an average star, one of millions in a single galaxy, has evolved slowly over time. MAN LOOKS TO THE STARS traces the concept of the universe from the Greeks to Ptolemy, Aristotle, Erastosthenes, Hiparcus, Copernicus, and Galileo. It recounts the social, religious, and political factors which were as important in changing man's thinking as the development of mathematics and the telescope. Art objects, astronomical photographs and epicycle models illustrate the evolution of man's thought from an earth centered world to a sun centered universe.

Concepts

- The earth is a body moving through space.
- The earth is one member of the solar system.

Objective

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain how man's view of the earth's place and motion in the solar system has changed as new evidence is discovered.

Learning Activities

Introduce the following terms: orbit, epicycle, constellation, planet.

Have students develop brief biographical sketches of Ptolemy, Aristotle, Erastosthenes, Copernicus, and Galileo.

Have students discuss what they think was the most important factor involved in the change from the Ptolemaic to the Copernican universe.

Have students make posters showing the constellations seen in the zodiac, include constellation's history and major stars.

Throw a class "star party" to assist students identify major constellations.

Use the monthly sky calendar in SCIENCE AND CHILDREN as a guide.

Have students build a scale model of the solar system using information found in "Let's Count the Stars" by Marion J. Joseph and Sara L. Lippincott in SCIENCE AND CHILDREN, Vol. 6, No. 5 (May, 1969).

Have students conduct #1-2 "Measuring the Earth" investigation from Miles F. Harris's et al. Earth Science Curriculum Project textbook INVESTIGATING THE EARTH (1973), published by Houghton Mifflin Company, Boston, Massachusetts.

Have students measure the apparent motion of the sun using the sun's shadow.

Play the simulation game SPACE HOP from Teaching Concepts, Inc.

Media Resources

FILMS

EXPLORING THE MOON. 16mm. 16 min. sd. color. Coronet Films, 1969.

GALAXIES AND THE UNIVERSE. 16mm. 13 1/2 min. sd. color. Coronet Films, 1969.

HOW MANY STARS. 16mm. 11 min. sd. color. Moody Institute of Science, 1974.

MARS MINUS MYTH. 16mm. 18 min. sd. color. Churchill Films, 1973.

THE NIGHT SKY. 16mm. 11 min. sd. color. Ency. Britannica Ed. Corp. (2nd ed.)

OUR SUN AND ITS PLANETS. 16mm. 11 min. sd. color. Coronet Films, 1970.

PLANETS IN ORBIT: THE LAWS OF KEPLER. 16mm. 10 min. sd. color. Ency. Britannica Ed. Corp.

THE SOLAR SYSTEM. 16mm. sd. color. Ency. Britannica Ed. Corp. (to be released)

SPACE SCIENCE: THE SUN AS A STAR. 16mm. 13 1/2 min. sd. color. Coronet Films, 1970.

STARS AND STAR SYSTEMS. 16mm. 16 min. sd. color. Ency. Britannica Ed. Corp.

A TRIP TO THE PLANETS. 16mm. 15 min. sd. color. Ency. Britannica Ed. Corp.

WHAT IS AN ECLIPSE? 16mm. 11 min. sd. color. BFA Educational Media

FILM LOOPS

MOON: MOTION AND PHASES. 1 color film loop. Hubbard Scientific Co.

PLANETARY MOTION. 1 color film loop. Hubbard Scientific Co.

SPACE EXPLORATION SERIES. 14 color film loops. Hubbard Scientific Co.

FILMSTRIPS

MAN, MOON, AND UNIVERSE II. 3 color filmstrips, 3 disc recordings, Educational Resources, 1970.

MAN STUDIES SPACE. 2 color filmstrips, 1 disc recording. Educational Activities, 1969.

THE UNIVERSE. 6 color filmstrips, 6 cassette tapes. National Geographic Society, 1972.

SLIDES

ASTRONOMICAL DIAGRAMS. 20 color slides. Ward's Natural Science Establishment, Inc.

THE PLANETS. 20 color slides. Ward's Natural Science Establishment, Inc.

SOLAR SYSTEM ASTRONOMY. 20 color slides. Ward's Natural Science Establishment, Inc.

THE SUN. 20 color slides. Ward's Natural Science Establishment, Inc.

TRANSPARENCIES

ASTRONOMY SET I. 11 color transparencies. Hubbard Scientific Co.

ASTRONOMY SET II. 10 color transparencies. Hubbard Scientific Co.

KITS

GLOBE LABORATORY. 8" diameter globe, overlays, inserts. Hubbard Scientific Co.

READING, RESEARCHING, AND REPORTING IN SCIENCE: THE UNIVERSE. 4 color filmstrips, 4 disc recordings, 8 books, 50 activity cards. BFA Educational Media, 1975.

Teacher References

Atkin, J. Myron, and Wyatt, Stanley P., Jr. 1969. *The Universe in Motion.* New York: Harper and Row.

Branley, Franklyn M. 1959. *Experiments in Sky Watching.* New York: Thomas Y. Crowell Co.

De Harsany, Zsolt. 1932. *The Star Gazer.* New York: G. P. Putnam's Sons.

Drake, Stillman, trans. 1957. *Discoveries and Opinions of Galileo.* Garden City, NJ: Doubleday and Co., Inc.

Hoyle, Fred. 1975. *Astronomy and Cosmology.* San Francisco: W. H. Freeman and Co.

Koestler, Arthur. 1960. *The Watershed: A Biography of Johannes Kepler.* Garden City: Doubleday and Co., Inc.

Kohn, Clyde F. 1967. *Guide to Effective Globe Usage.* Chicago: A. J. Nystrom Co.

Leonard, Jonathan N., and Sagan, Carl. 1969. *Planets.* Morristown, NJ: Silver Burdett Co. (a title in the Life Science Library)

Mallon, Gerald L. 1976. An introduction to constellation study. *Science and Children* 14(Nov.): 23-25.

2-2

A Chip Bobbing on the Ocean of Space

Segment Synopsis

Students glimpse, in this segment, the wide variety of motions their planet makes as it travels through space. Animated sequences depict the earth's axial rotation, precession, nutation, and elliptical orbit; motion of the earth-moon system; motion of the solar system about the milky way galaxy; and the galaxy's motion through space. No attempt is made to explain the various motions but only to demonstrate their existence.

Concepts

- Motion is the natural state of the planet earth.
- The earth has many motions.

Objective

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain the principle motions of the earth.

Learning Activities

Have students learn the meanings of rotation, orbit, precession, and nutation.

Ask students how they can prove that the earth is rotating. Which of the earth's motions can be observed without special instruments?

Several students might wish to make time lapse photographs of Polaris (the Pole Star) to illustrate the earth's rotation.

Have students conduct #2-4 "Whose Move is it?" from Leonard Bernstein and Harry K. Wong's textbook, EARTH SCIENCE: IDEAS AND INVESTIGATIONS IN SCIENCE (1977), published by Prentice-Hall Inc., Englewood Cliffs, New Jersey.

Foucault and His Pendulum

Segment Synopsis

This essay combines biographical information on Foucault with scientific principles about the earth's movements which influenced the design of the pendulum. Using models and actual working pendulums, it demonstrates the behavior of the Foucault pendulum and explains the different pendulum motions which occur from the equator to the poles. A special effort has been made throughout this segment to avoid using advanced mathematics (trigonometry) when explaining the concepts involved.

Concept

- Motion is the natural state of the planet earth.

Objective

After watching this segment and completing appropriate follow-up activities, the students should be able to

- explain how the Foucault pendulum demonstrates the earth's rotation on its axis

Learning Activities

Prior to viewing this segment, students should understand the meaning of the following words: pendulum, rotation, axis, gravity, pole, equator.

Let students construct several pendulums using crude equipment. Try to build one with a rotatable base. Use the references listed in the Teacher References section.

Have students conduct investigation #2-4 "Whose Move is it?" from Leonard Bernstein and Harry K. Wong's textbook EARTH SCIENCE: IDEAS AND INVESTIGATIONS IN SCIENCE (1977), published by Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Have students suggest other ways to prove that the earth is rotating on its axis. See #1-7 "Investigating the Sun's Path--Sun Watch" in INVESTIGATING THE EARTH (1973) by MIles F. Harris, et al. published by Houghton Mifflin Company, Boston, Massachusetts.

Media Resources

FILM LOOPS

EARTH: ROTATION AND REVOLUTION. 1 color film loop. Hubbard Scientific Co.

SIMPLE PENDULUM SERIES. 4 color film loops. BFA Educational Media, 1972.

Teacher References

Bete, Channing L. 1964. *About Foucault Pendulums and How They Prove the Earth Rotates!* A Scriptographic Study Unit. Greenfield, MA: Channing L. Bete Co., Inc.

Frankovits, Nicholas D. 1976. A simplified pendulum for classroom use. *Journal of Geological Education* 24: 103-104.

Stong, C. L. 1964. How to build an accurate Foucault pendulum. In *Amateur Scientist. Scientific American* Feb.: 132-139.

2-4

Microbes to Stars

Segment Synopsis

Within the universe, humans occupy a unique position between the very large and the very small. This short segment helps students visualize their scale in relation to the earth and the universe. A box is used to illustrate scale, its dimensions are multiplied in units of one thousand on a side, thus increasing the box's volume one billion times with each multiplication. The first box is only capable of holding one bacterium; the fifth box, the earth; the tenth, the Milky Way galaxy; and the eleventh, all our neighboring galaxies.

Concept

- This segment is supplementary and relates only indirectly to concepts pertinent to the study of the earth as a body in space.

Learning Activities

Have students design posters illustrating the scale of microbes, humans, and the universe to one other.

Have students build a model of the Milky Way Galaxy using one millimeter to represent one light year.

Have students count the stars using a cardboard sheet with a 12 inch square hole cut in it. When held at arms length from the eye, the viewer should be able to count the stars in an area measuring 20° x 20° which amounts to 1/103 of a sphere.

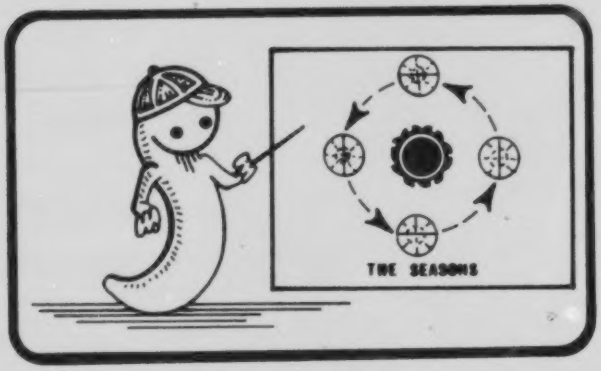
Have students build a model of the earth at a scale of 9.95 km./cm. using the following data:

Hydrosphere & Biosphere

Ionesphere fades out to space approximately (300 miles)
Ionesphere fades out to space approximately 482 kilometers above surface--
scale = 48.44 cm
The mesosphere is approximately 40.23 meters thick -- scale = 4.0 cm
The stratosphere is approximately 32.2 meters thick -- scale = 3.2 cm

The troposphere is approximately 17.7 meters thick -- scale 1.7 cm
The highest point on surface of planet Mt. Everest 8.832 km -- scale = 0.99 cm
The deepest point on surface of planet Mindanao Trench 10.4 km -- scale = 1.0 cm
The crust at its thinnest point beneath the ocean is approximately 10 km thick -- scale = 1.0 cm
The crust at its thickest point beneath the continents is approximately 48.4 km thick -- scale 4.8 cm
The mantle including the crust is approximately 2896 km thick -- scale = 2.91 meters
The outer core is approximately 2092 km thick -- scale = 2.10 meters
The inner core is approximately 1384 km thick -- scale = 1.39 meters

2-5



The Seasons

Segment Synopsis

THE SEASONS explains how the seasons result from the tilting of the earth's axis in the plane of its orbit. It asks students to suggest how the seasons would be different if: the earth did not rotate on its axis, the axis did not point in one direction, the earth was not inclined to the plane of its orbit but was perpendicular, and what it would be like if they lived in the southern hemisphere.

Concepts

- Motion is the natural state of the planet earth.
- The earth's seasons results from the earth's revolution, tilt, and parrellelism of its axis.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- describe how the seasons result from the earth's movement
- describe the cause of energy change on the planet's surface.

Learning Activities

Before viewing this segment, introduce the idea that sunlight changes to heat energy when it strikes the earth. Using a gyro, demonstrate how the earth's rotation causes its axis to point in the same direction throughout its orbit.

Using a grid card and light source to demonstrate how the angle at which light strikes the earth affects its intensity. Maintain the distance but vary the angle between the light and hard surface. As the angle becomes smaller, the amount of light per unit area decreases. Relate the angle to the earth's position at different seasons; point out that the earth's distance from the sun has little effect.

Have students act out the seasons. One student with a flashlight is the sun, another, holding a globe, orbits as the earth.

Have students calculate an equation of an analemma time model. See Franklyn M. Branley's EXPERIMENTS IN SKY WATCHING (1959), published by Thomas Y. Crowell Co., New York, New York.

Media Resources

FILM LOOPS

SEASONS. 1 color film loop. Hubbard Scientific Co.

SUMMER AND WINTER. 1 color film loop. Doubleday and Co., Inc.

TRANSPARENCIES

ASTRONOMY SET I. 11 color transparencies. Hubbard Scientific Co.

SEASONS OF THE YEAR. 1 color transparency. Hammond Inc.

Teacher Reference

Kohn, Clyde F. 1967. *Guide to Effective Globe Usage.* Chicago: A. J. Nystrom and Co.

3

Forces That Act on the Earth

Tides and the Moon
Newton: A Biography
Gravity: What Is It?
"Crunch"
The Earth's Magnetic Field

Program Overview

Program Three is the second program focusing on the properties of the planet earth. FORCES THAT ACT ON THE EARTH includes information on tides, gravity, and magnetism. An interview with an geophysicist and a cartoon segment on the shape of the earth round out the program.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 10-5: Movements of the Ocean: Waves and Tides, pp. 314-319
- MODERN EARTH SCIENCE
  - Ch. 1: Design of the Universe, pp. 14-17
  - Ch. 17: Motions of the Sea, pp. 365-367
- PATTERNS IN OUR ENVIRONMENT
  - Ch. 4: Invisible Patterns, pp. 78-109
- THE WORLD WE LIVE IN
  - Ch. 28: Exploring Space, pp. 426-428
  - Ch. 29: Our Moon, pp. 460-462
- EARTH SCIENCE: A LABORATORY APPROACH
  - No references
- EARTH SCIENCE: IIS
  - Idea 2-8: Love Makes the World Go Round, pp. 77-80
  - Idea 6-6: The Ocean Comes Up, pp. 225-230
- FOCUS ON EARTH SCIENCE
  - Ch. 1: Origin and Motions of the Earth, pp. 4-23
  - Ch. 23: The Moon, pp. 470-486
- HOLT: EARTH SCIENCE
  - Ch. 13: The Earth in Space, pp. 370-403
- INVESTIGATING THE EARTH
  - Ch. 1: The Moon, Our Natural Satellite, pp. 14-16
  - Ch. 3: Earth Forces, pp. 59-66
- OUR ENVIRONMENT IN SPACE
  - Ch. 5: The Earth in Motion, pp. 104-106
  - Ch. 8: The Solar Wind, pp. 156-165
  - Ch. 19: Work of Waves, pp. 405-409
- PATHWAYS IN SCIENCE
  - Unit 8: Energy and Motion in Our Solar System, pp. 387-453.

Student Readings

Branley, Franklyn M. *Gravity is a Mystery.* New York: Thomas Y. Crowell Co., 1970.

__________. *Weight and Weightlessness.* New York: Thomas Y. Crowell Co., 1972.

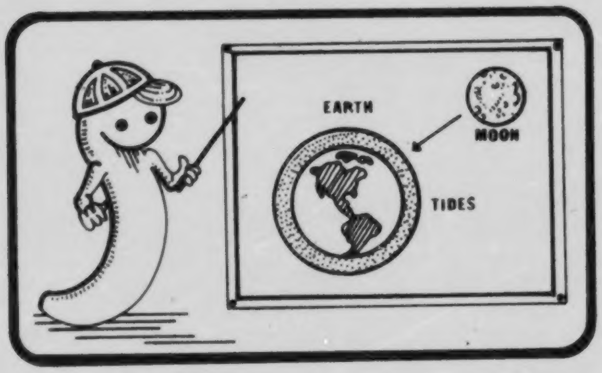
Mann, A. L., and Vivian C. Mann. *Famous Physicists.* New York: John Day Co., Inc., 1963.

Milgram, Harry. *First Experiments with Gravity.* New York: E. P. Dutton and Co., Inc., 1966.

Pine, Tillie S., and Levine, Joseph. *Gravity All Around.* New York: McGraw-Hill Book Co., 1963.

Reuben, Gabriel H., and Gloria Archer. *What is a Magnet.* Westchester, IL: Benefic Press, 1959.

Valens, Evans G., Jr., and Berenice Abbott. *The Attractive Universe: Gravity and the Shape of Space.* Cleveland: William Collins and World Publishing Co., Inc., 1969.



Tides and the Moon

Segment Synopsis

TIDES AND THE MOON explains the acts of gravity on the ocean to produce tidal bulges and describes the movement of the bulges around the earth which create the daily tidal cycle. It demonstrates the size and shape of ocean basins affecting tidal size. Students are asked to suggest potential uses of tide power.

Concepts

- Forces cause objects to move tides.
- Tides are created by the gravitational attraction between the earth, moon, and sun.
- Tides are modified by the shape and size of the basin in which they occur.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain how tides are created
- demonstrate how the position of the sun and moon affect the tides.

Learning Activities

Have students reconstruct a tidal cycle using an aquarium. On the side of the tank, record water levels representing the tide heights on an hourly basis for a twelve hour period. Add the following amounts of water representing the first six hours: 1st hour = 134 ml; 2nd hour = 366 ml; 3rd hour = 500 ml; 4th hour = 500 ml; 5th hour = 366 ml; 6th hour = 134 ml; then remove the water amounts in the same order. The result will be a curve representing the ocean's surface level for twelve hours of the tidal cycle.

Have students conduct an investigation of tides using either the suggestions given in "An Investigation of Tides: Are They Related to the Moon?" by Robert G. Anderson in THE SCIENCE TEACHER, Vol. 35, No. 4 (April, 1968), pp. 21-23 or "Tide Sutdy, An Activity" by Walter Gehring in THE SCIENCE TEACHER, Vol. 40, No. 8 (November, 1975), p. 44.

Have students conduct the following investigation from Leonard Bernstein and Harry K. Wong's textbook, EARTH SCIENCE: IDEAS AND INVESTIGATIONS IN SCIENCE (1977), published by Prentice-Hall, Inc., Englewood Cliffs, New Jersey:

2-8 Love Makes the World Go 'Round
6-6 The Ocean Comes Up

Media Resources

FILMS

OCEAN TIDES: BAY OF FUNDY. 16mm. 14 min. sd. color. Ency. Britannica Ed. Corp.

ORIGIN OF THE MOON. 16mm. 5 min. sd. color. Bailey Film Associates, 1969.

SOLAR ENERGY: TO CAPTURE THE POWER OF SUN AND TIDE. 16mm. 24 min. sd. color. ACI Films, Inc.

TIDES OF THE OCEANS. 16mm. 17 min. sd. color. Life Science Academy Films.

Teacher References

Clancy, Edward P. 1968. *The Tides: Pulse of the Earth.* Garden City, NY: Doubleday and Co., Inc.

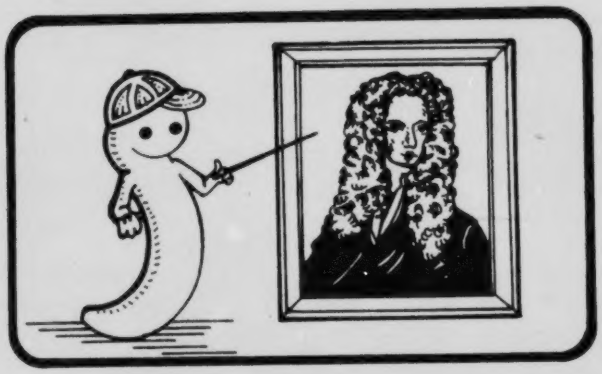
Goldreich, Peter. 1972. Tides and the earth-moon system. *Scientific American* April: 42-52.

National Ocean Survey. 1976. *Our Restless Tides.* Washington, DC: National Oceanic and Atmospheric Administration.

__________. 1978. *Tidal Currents.* Washington, DC: National Oceanic and Atmospheric Administration. (pamphlet)

Purrett, Louise A. 1976. The old familiar puzzle of the tides. *NOAA Journal* 6 (Jan.): 42-45.

U. S. Navy Hydrographic Office. 1958. *Oceanography: American Practical Navigator. Part 6.* Washington, DC: U. S. Government Printing Office.



Newton: A Biography

Segment Synopsis

Sir Isaac Newton was responsible for discovering many of the laws underlying our knowledge of gravity. This brief biographical sketch stresses the wide variety of discoveries credited to Newton.

Concepts

- Man's mind is his most important tool for investigating the earth.
- Man's senses are used to make observations, his mind to interpret observations.

Objective

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain how Newton applied his senses and intellect to explain various earth phenomena.

Learning Activity

This biographical segment is intended to complement Segment Three, GRAVITY, WHAT IS IT? You may wish to have students prepare displays or reports on Newton's life and work.

Media Resource

FILM
INERTIAL, MASS AND THE LAWS OF MOTION.
16mm. 13 min. sd. color.
Coronet Films.

Teacher Reference

Andrade, Edward N. 1958. *Sir Isaac Newton: His Life and Work.* Garden City, NY: Doubleday and Co., Inc.

3-3

Gravity: What Is It?

Segment Synopsis

Dr. Charles Welby is interviewed in GRAVITY: WHAT IS IT? Dr. Welby explains gravity and the inverse square law as it applies to gravitational force. He defines the geoid and shows how gravity data is used for geoid mapping. Because of gravitational forces, the earth is believed to be distorted; its shape is related to both an oblate spheroid and a bowling ball.

Concepts

- Forces cause objects to move.
- Most conditions of matter can be described in terms of fields.
- The earth has a gravitational field.
- Gravity at the earth's surface is affected by many factors.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- describe a field and give examples of various types of fields
- describe the effects of the earth's gravitational field in elementary terms.

Learning Activities

Have students conduct #3-9 "Investigating the Behavior of a Falling Object" from Miles F. Harris's, et al. Earth Science Curriculum Project textbook INVESTIGATING THE EARTH (1973), published by Houghton Mifflin Company, Boston, Massachusetts.

Students may wish to conduct "falling" races by timing objects dropped from the top of a step ladder. Students should come to the conclusion that all bodies accelerate at the same rate due to the pull of gravity, unless wind resistance is a factor.

Have students carry out a simple investigation of gravity as outlined in "Phenomena for Inquiry: Falling Objects" in SCIENCE AND CHILDREN, Vol. 12, No. 6 (March, 1975), p. 39.

Have students experiment with weightlessness and artificial gravity (centrifugal force) using playground swings to simulate these qualities.

Conduct #2-8 investigation "Love Makes the World Go 'Round" in Leonard Bernstein and Harry K. Wong's textbook EARTH SCIENCE: IDEAS AND INVESTIGATIONS IN SCIENCE (1977), published by Prentice-Hall, Incorporated, Englewood Cliffs, New Jersey.

Media Resources

FILMS

ATTRACTION OF GRAVITY. 16mm. 8 3/4 min. sd. color. BFA Educational Media.

GRAVITY, WEIGHT, AND WEIGHTLESSNESS. 16mm. 11 min. sd. color. BFA Educational Media.

OPPORTUNITIES IN ZERO GRAVITY. 16mm. 18 min. sd. color. National Aeronautics and Space Administration.

FILM LOOPS

MOTION OF FALLING BODIES. 4 color film loops. BFA Educational Media.

FILMSTRIP

MEASURING DIFFERENCES IN GRAVITY. 1 color filmstrip, 1 disc recording. Ency. Britannica Ed. Corp.

Teacher References

Atkin, J. Myron, and Wyatt, Stanley P., Jr. 1969. *Gravitation.* New York: Harper and Row.

Gamow, George. 1962. *Gravity.* Garden City, NY: Doubleday and Co., Inc.

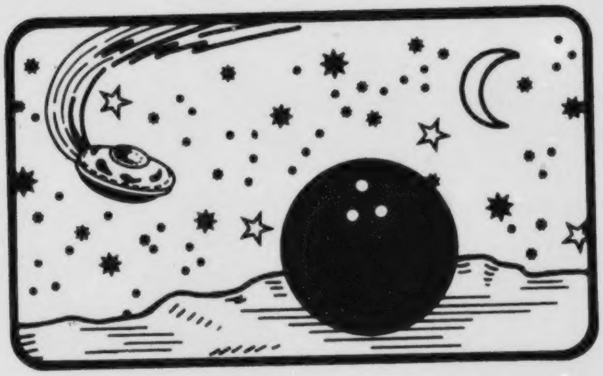
Shepherd, Walter. 1970. *Geophysics.* New York: G. P. Putnam's Sons.

Van Flandern, Thomas C. 1976. Is gravity getting weaker. *Scientific American* Feb.: 44-52.

Will, Clifford M. 1974. Gravitation theory. *Scientific American.* Nov.: 25-33.

3-4

"Crunch"



Segment Synopsis

Two space creatures "Fric" and "Frac" explore what they believe to be the earth. Unfortunately it turns out to be a bowling ball.

Concepts

- Man's mind is his most important tool for investigating the earth.
- Man's senses are used to make observations; his mind, to interpret observations.

Objective

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain how a lack of perspective may lead to incorrect conclusions.

Learning Activities

Have students look for other examples of situations where our senses may fail to give a complete picture of a situation or phenomenon.

Have students discuss how misinterpretation of data may result in erroneous decisions or conclusions.

The Earth's Magnetic Field

Segment Synopsis

THE EARTH'S MAGNETIC FIELD explores the field's generation and methods for detecting its presence. It describes the concept of declination and demonstrates how one can use it with a map and compass to determine location and direction.

Concepts

- Forces cause objects to move.
- Most conditions of matter can be described in terms of fields.
- The earth has a magnetic field.

Objective

After watching this segment and completing appropriate follow-up activities, the student should be able to

- describe the earth's magnetic field and demonstrate its presence with a compass.

Learning Activities

Have students investigate magnetic fields using two bar magnets, a piece of cardboard, and iron filings.

Have students use simple compasses to follow a plotted course around the school.

Hold an orienteering competition in the school area.

Have students plot hiking courses on topographic maps, taking into account the magnetic declination.

Media Resources

FILMS

THE EARTH: ITS MAGNETIC FIELD. 16mm. 13 1/2 min. sd. color. Coronet Films, 1969.

WHICH WAY IS NORTH? 16mm. 14 min. sd. color. Ency. Britannica Ed. Corp.

Teacher References

Beiser, Germaine. 1964. *The Story of the Earth's Magnetic Field.* New York: E. P. Dutton and Co., Inc.

Bleil, D. F. 1967. Magnetics. *The Science Teacher* Nov.: 17-22.

Coast and Geodetic Survey. 1962. *Magnetic Poles and the Compass.* Series No. 726. Washington, DC: U. S. Government Printing Office. (pamphlet)

Howe, Herbert H., and Hurwitz, L. 1964. *Magnetic Surveys.* Serial No. 718. Washington, DC: U. S. Dept. of Commerce. (pamphlet)

Larkin, Robert P., and Schoenstein, Roger. 1976. *How to Teach Map and Compass Skills.* Washington, DC: National Science Teachers Association. (pamphlet)

Shepherd, Walter. 1970. *Geophysics.* New York: G. P. Putnam's Sons.

4

Location and Time

A Net to Help Us Find Our Way
North Carolina's Geodetic Survey
Time and the Earth's Rotation
Meet Marvin Marker

Program Overview

This program acquaints students with the geographic network used for determining location and keeping time. A NET TO HELP US FIND OUR WAY introduces longitude and latitude and describes how the theoretical grid can establish actual locations on the earth's surface. Both NORTH CAROLINA'S GEODETIC SURVEY and MARVIN MARKER inform students of ways latitude and longitude are made available to the average citizen. TIME AND THE EARTH'S ROTATION shows how longitude, coupled with the earth's rotation, allows us to measure time.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 1-4: Maps as Models, pp. 17-25.
- MODERN EARTH SCIENCE
  - Ch. 6: Models of the Planet Earth, pp. 116-137
- PATTERNS IN OUR ENVIRONMENT
  - Ch. 3: Patterns in Time, pp. 52-77
- THE WORLD WE LIVE IN
  - Ch. 31: Location and Navigation, pp. 476-484
  - Ch. 32: Keeping Time, pp. 485-493
- EARTH SCIENCE: A LABORATORY APPROACH
  - Ch. 1: Models and Maps, pp. 1-21
  - Ch. 12: The Meaning of Time, pp. 275-286
- EARTH SCIENCE: IIS
  - Idea 1-6: It's Going to Take Some Time, pp. 31-35
- FOCUS ON EARTH SCIENCE
  - Ch. 1: Origins and Motions of the Earth, pp. 4-23
  - Ch. 2: Forms and Layers of the Earth, pp. 24-42
- HOLT: EARTH SCIENCE
  - Ch. 13: The Earth in Space, pp. 370-403
  - Ch. 14: The Solar System, pp. 404-411
- INVESTIGATING THE EARTH
  - Ch. 3: Earth Forces, pp. 59-71
- OUR ENVIRONMENT IN SPACE
  - Ch. 7: The Energy Exchange, pp. 135-137
- PATHWAYS IN SCIENCE
  - Unit 8: Energy and Motion in Our Solar System, pp. 387-453

Student Readings

Asimov, Isaac. *The Clock We Live On.* rev. ed. New York: Abelard-Schuman, Ltd., 1965.

Branley, Franklyn M. *North, South, East and West.* New York: Thomas Y. Crowell Co., 1966.

Coggins, Jack. *By Star and Compass: The Story of Navigation.* New York: Dodd, Mead and Co., 1967.

Hirsch, S. Carl. *On Course: Navigating the Sea, Air, and Space.* New York: Viking Press, Inc., 1967.

Irwin, Keith G. *Three Hundred Sixty Five Days: The Story of Our Calendar.* New York: Thomas Y. Crowell, Co., 1963.

Marshal, Roy K. *Sundials.* New York: Macmillan Publishing Co., Inc., 1963.

National Ocean Survey. *Meet Marvin Marker.* U. S. Dept. of Commerce, National Oceanic and Atmospheric Administration, 1970. (pamphlet)

LATITUDE
LONGITUDE

A Net to Help Us Find Our Way

Segment Synopsis

A NET TO HELP US FIND OUR WAY describes the construction and function of the geographic grid. It is simply explained as a means for finding N-S and E-W location, however the geometry involved in calculating the grids is summarized for advanced student viewers. The segment closes with a "humorous" example about locating a fishing boat on the N. C. coast using latitude and longitude.

Concepts

- The earth's motions, grativational fields, and magnetic fields make possible our frame of reference.
- Man needs a precise system of location to orient himself.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain how longitude and latitude are related to the rotation of the earth
- demonstrate how the location grid is used to establish a point on the earth's surface.

Learning Activities

Have students design displays showing how latitude and longitude are used to define a location.

Have students prepare a report on Greenwich, England.

Using a globe, have students work out the geographic location of various prominent features on the earth.

Give students unmarked spheres and ask them to construct their own system for locating points on its surface.

Media Resources

FILM LOOPS

LATITUDE. 1 color film loop. Doubleday Multimedia.

LONGITUDE. 1 color film loop. Doubleday Multimedia.

Teacher References

Kinsler, John L. 1972. A latitude of 45° north. *Science and Children* 10(Dec.): 15-19.

Kohn, Clyde F. 1967. *Guide to Effective Globe Usage*. Chicago: A. J. Nystrom and Co.

4-2

North Carolina's Geodetic Survey

Segment Synopsis

John Garner takes students on a tour of the North Carolina Geodetic Survey. This branch of North Carolina state government places geodetic markers (points of precisely known latitude and longitude) and benchmarks (points of known elevation above main sea level) in the state for use by many different agencies and individuals.

Concepts

- Man needs a system of location on the earth to orient himself.
- Precise measurements often provide perspective and a sense of scale.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- demonstrate how the location grid is used to find a point on the surface of the earth
- give examples of ways in which precise measurements are used to locate geographic points in the earth's surface.

Learning Activities

Have students find the triangulation stations and horizontal control points on a map of their area and then actually find them located in the field.

Invite a surveyor to speak to the class about the way local land boundaries are tied to the geodetic control network.

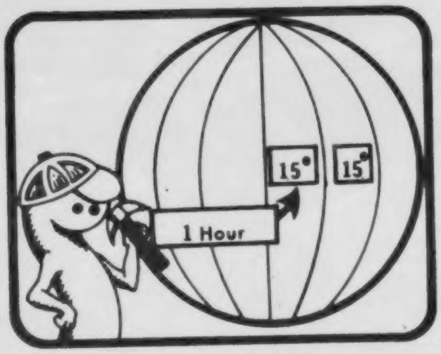
Media Resources

FILMS

DESTINATION: WHERE? 16mm. 11 min. sd. color. U. S. Air Force.

MODERN GEODETIC SURVEYING. 16mm. 18 min. sd. color. U. S. Navy.

PATHFINDERS FROM THE STARS. 16mm. 48 min. sd. color. National Oceanic and Atmospheric Administration.



Time and the Earth's Rotation

Segment Synopsis

TIME AND THE EARTH'S ROTATION introduces students to the idea of time both as a precise measureable unit and as a relative passing of events. For most people, time varies with their activity. However a more constant measure is the one relating time to the rotation of the earth. This segment demonstrates how scientists measure time. It shows the value of time zones and explains the correction made by the international dateline.

Concept

- The earth's longitude grid and its rotation are used to determine time.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain how longitude and rotation are related to time
- list and explain the organization of the time zones within the continental United States
- explain the function of the international dateline
- explain how time is measured and standardized in our modern world.

Learning Activities

Have students conduct investigation #1-6 "It's Going to Take Some Time" in Leonard Bernstein and Harry K. Wong's textbook EARTH SCIENCE: IDEAS AND INVESTIGATIONS IN SCIENCE (1977), published by Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Have students figure out what time it is in prominent cities around the world relative to their own time zone.

Media Resources

FILM LOOPS

DAY AND NIGHT. 1 color film loop. Hubbard Scientific Co.

DAY AND NIGHT. 1 color film loop. Doubleday Multimedia.

TIME. 1 color film loop. Doubleday Multimedia.

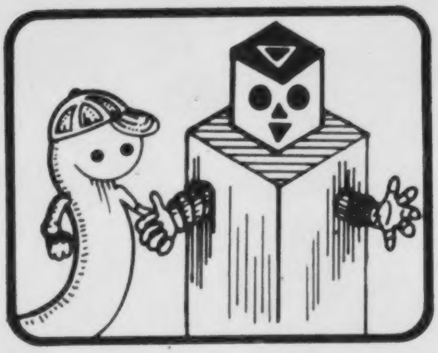
TIME AND DATELINE. 1 color film loop. Hubbard Scientific Co.

Teacher References

Kohn, Clyde F. 1967. *Guide to Effective Globe Usage*. Chicago: A. J. Nystrom and Co.

Roberds, Wesley M. 1974. Time around the world. *Science and Children* 11(Jan.-Feb.): 25-27.

Ulmer, David C., Jr. 1975. How high is it? What time is it? Sun altitude and sun time for non-mathematicians. *Science and Children* 12(Mar.): 14-17.



Meet Marvin Marker

Segment Synopsis

This is a humorous segment designed to promote, protect, and preserve geodetic markers and benchmarks. Two boys walking home from school meet Marvin Marker, a talking benchmark, who tells them about his troubles and shows them how they can help.

Concept

- Man needs a precise system of location to orient himself.

Objective

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain why it is important to protect triangulation and horizontal control station markers.

Learning Activities

Have a contest to locate geodetic markers in the community. You may wish to use topographic maps as an aid.

Have students report endangered markers to the National Oceanic Survey, Rockville, Maryland.

5

Maps for Man

Meet Tanya Topo Sheet

Mapping the Earth From Space

Program Overview

Mapping is a major concept and maps are vital tools in earth science. There are many instructional materials on topographical mapping. Most of these materials concentrate on the function of topographic maps and teach the principles of contour lines, color codes, and symbols. Experience has shown that the best way to teach a student how to use a map is to have him use one. To avoid duplication and ineffective teaching, Program 5 focuses on giving students an appreciation for map making and speculates on the future of mapping rather than how to use a map.

Textbook References

- A SEARCH FOR UNDERSTANDING
    Ch. 1-5: Showing Distance and Height on a Map, pp. 25-29
- MODERN EARTH SCIENCE
    Ch. 6: Models of the Planet Earth, pp. 116-137
- PATTERNS IN OUR ENVIRONMENT
    Ch. 4-13: Making a Contour Map, p. 94
    Ch. 4-14: Comparing an Aerial Photo, a Road Map, and a Topographic Map, p. 95
    Ch. 4-15: Mapping Your Neighborhood, p. 97
    Ch. 4-16: Comparing a Satellite Photo and a Map, p. 98
- THE WORLD WE LIVE IN
    Ch. 6: Topographic Maps, pp. 72-85
- EARTH SCIENCE: A LABORATORY APPROACH
    Ch. 1: Models and Maps, pp. 1-21
- EARTH SCIENCE: IIS
    No references
- FOCUS ON EARTH SCIENCE
    Appendix F: Topographic Maps, pp. 534-539
- HOLT: EARTH SCIENCE
    No references
- INVESTIGATING THE EARTH
    Ch. 14-2: Investigating Maps as Models, pp. 302-304
- OUR ENVIRONMENT IN SPACE
    Extending Unit 4: Contour Mapping, p. 441
- PATHWAYS IN SCIENCE
    II Ch. 10: Maps to Describe the Earth's Surface, pp. 120-124
    II Ch. 11: Topographic Maps, pp. 125-131

Student Readings

Darden, Lloyd. *The Earth in the Looking Glass.* Garden City, NY: Doubleday and Co., Inc., 1974.

Hubbard Scientific Company. *Reading Maps.* Northbrook, IL: Hubbard Scientific Co., n. d.

MacMahan, Horace. *Stereogram Book of Contours.* Northbrook, IL: Hubbard Scientific Co., 1972.

National Aeronautics and Space Administration. *Earth Photographs From Gemini III, IV, and X.* Washington, DC: National Aeronautics and Space Administration, 1967.

________. *Earth Photographs for Gemini VI Through XII.* Washington, DC: National Aeronautics and Space Administration, 1968.

________. *Photography From Space to Help Solve Problems on Earth.* Goddard Space Flight Center, MD: National Aeronautics and Space Administration, 1976.

________. *NASA Facts.* Washington, DC: National Aeronautics and Space Administration. (a pamphlet and poster series)

National Oceanic and Atmospheric Administration. *Space: Environmental Vantage Point.* Washington, DC: U. S. Dept. of Commerce.

Nicks, Oran W., ed. *This Island Earth.* Washington, DC: National Aeronautics and Space Administration, 1970.

Short, Nicholas M., Paul D. Lawman, Jr., Stanley C. Freden, and William A. Finch, Jr. *Mission to Earth: Landsat Views the World.* Washington, DC: National Aeronautics and Space Administration, 1976.

Thompson, Morris M., and Julius L. Speert. "Mapping the Surface of the Earth." *National History,* Oct. 1964, pp. 30-37.

U. S. Geological Survey. *Topographic Mapping: A Challenging Future.* Washington, DC: U. S. Government Printing Office, 1964.

5-1

Meet Tanya Topo Sheet

Segment Synopsis

Tanya Topo Sheet is a topographic map of a 7 1/2 minute quadrangle in the northwestern piedmont of North Carolina. This segment describes the process of producing a topographic map, from the beginning decision concerning what to map, to the final printing of the map. Standard colors and contour lines are mentioned; a quadrangle is defined. Events move swiftly and no attempt is made to provide an indepth treatment. Instead this segment's purpose is to acquaint students with the process of map construction and promote a better appreciation for the value of the maps they use.

Concept

- A map is a graphic model of the earth, designed to represent some aspect of the planet.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- define and explain what constitutes a map
- explain in general terms how topographic maps are made
- identify the major features of a map and explain the meaning of the more commonly used map symbols
- construct a simple map using correct techniques and symbols
- read a standard topographic map

Learning Activities

Have students conduct #14-2 "Investigating Maps as Models" from Miles F. Harris's, et al. Earth Science Curriculum Project textbook INVESTIGATING THE EARTH (1973), published by Houghton Mifflin Company, Boston, Massachusetts.

Have students make their own topographic maps of the school grounds, using simple equipment. You may wish to reward the student with the neatest and most accurate map. The winning map may then be duplicated and used as a base for later mapping of temperature fields, soil types, land use patterns, etc.

Have students locate typical symbols, features, and landforms on various types and scales of local area maps including highway maps, county road maps, and U.S.G.S. 7 1/2 minute topographic maps.

Have students locate as many different kinds of maps as possible and display them on a bulletin board about maps uses.

Media Resources

FILMS

MAPPING A BETTER TOMORROW. 16mm. 28 1/2 min. sd. color. Dept. of the Army.

MAPPING THE WORLD. 16mm. 26 min. sd. color. U. S. Army Engineer Division, St. Paul.

FILM LOOPS

CONTOURS. 1 color film loop. Doubleday Multimedia.

LAND ELEVATION: SYMBOLS AND EXAMPLES. 1 color film loop. Doubleday Multimedia.

SLIDES

CULTURAL FEATURES SYMBOLS. 20 color slides. Hubbard Scientific Co.

RELIEF AND DRAINAGE SYMBOLS. 20 color slides. Hubbard Scientific Co.

WHAT ON EARTH? SLIDE SET A/5/1.

TRANSPARENCIES

MAP READING PART I . 4 color transparencies. Hubbard Scientific Co.

MAP READING PART II. 8 color transparencies. Hubbard Scientific Co.

MODELS

MAP PROJECTION MODEL. 16" x 9" x 9". Hubbard Scientific Co.

MAP READING MODEL. 10" x 10" x 12". Hubbard Scientific Co.

MAPS

OUTLINE MAPS FOR THE CONSTRUCTION OF A MODEL OF THE WORLD. Washington, DC: U. S. Coast and Geodetic Survey.

PHYSIOGRAPHIC MAPS. Erwin Raisz.

POLITICAL AND PHYSIOGRAPHIC MAPS AND GLOBES. National Geographic Society.

RAISED RELIEF MAPS. Hubbard Scientific Co.

SOIL MAPS. U. S. Dept. of Agriculture, Soil Conservation Services.

Note: Use free indexes to order U. S- Geological Survey maps in scales of 1:1,000,000 and 1:1,250,000 and by states in 15 min. and 7 1/2 min. sizes. Special maps are also available for selected landforms and national parks.

POSTER

EARTHSHAPES. Creative Publishers, Inc.

Teacher References

Brown, Martin F., and Thompson, Ray W. 1970. *Topographic Maps for Earth Science.* Morristown, NJ: Silver Burdett Co.

O'Connor, James, and Shugrue, Sylvia K. 1973. Toward topographic map making: Reading contour maps and how to survey and map the schoolgrounds. *Science and Children* 11(Oct.): 12-17.

__________. 1973. Toward topographic map making: Symbols, the language of maps. *Science and Children* 10(May): 18-20.

U. S. Army. 1969. *Map Reading Field Manual FM 21-26.* Washington, DC: U. S. Government Printing Office.

U. S. Geological Survey. 1969. *Topographic Maps.* Washington, DC: U. S. Government Printing Office. (pamphlet)

__________. 1970. *Geologic Maps: Portraits of the Earth.* Washington, DC: U. S. Government Printing Office. (pamphlet)

__________. 1971. *Topographic Maps: Tools for Planning.* Washington, DC: U. S. Government Printing Office.

__________. 1972. *Types of Maps Published by Government Agencies.* Washington, DC: U. S. Government Printing Office.

__________. 1975. *Maps of the United States.* Washington, DC: U. S. Government Printing Office. (pamphlet)

__________. 1975. *Selected Bibliography on Maps and Mapping.* Washington, DC: U. S. Geological Survey. (pamphlet)

__________. 1975. *State Maps.* Washington, DC: U. S. Government Printing Office. (pamphlet)

__________. 1975. *Topographic Maps of National Parks, Monuments, and Historic Sites.* Washington, DC: U. S. Government Printing Office. (pamphlet)

Upton, William B., Jr. *Landforms and Topographic Maps.* New York: John Wiley and Sons, Inc.

Westerback, Mary. 1976. A model to aid topo map interpretation. *The Science Teacher* 43(Sept.): 42-43.

5-2

Mapping the Earth From Space

Segment Synopsis

Dr. William Fisher, a native North Carolinian and senior scientist for the Earth Resources Technology Satellite Program, shows the latest techniques changing the mapping process. He explains how space photographs are applied to mapping and demonstrates new orthophoto maps, two innovations at the frontiers of mapping research.

Concept

- A map is a graphic model of the earth, designed to represent some aspect of the planet.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain, in general terms, how satellites are being used to construct maps of the earth
- list some of the more common applications of satellite photographs.

Learning Activities

Have students locate local, regional and state features on an ERTS photograph.

Have students use aerial photographs to map some feature that varies with time, such as plant cover, snow cover, flood waters, or shorelines.

Media Resources

FILMS

ERTS: EARTH RESOURCES TECHNOLOGY SATELLITE. 16mm. 27 min. sd. color. National Aeronautics and Space Administration.

A NEW LOOK AT AN OLD PLANET. 16mm. 28 min. sd. color. National Aeronautics and Space Administration.

SLIDES

EROS SATELLITE COLOR COMPOSITE PHOTOGRAPH. color slides. U. S. Geological Survey, EROS Data Center. (See EROS DATA CENTER booklet in Teacher References)

LANDSAT COLOR PHOTO MOSAICS AND INDIVDUAL PHOTOS. color slides. General Electric Company, Photographic Engineering Laboratory.

MAPS

LANDSAT IMAGE MAP. U. S. Geological Survey.

MESA QUADRANGLE, ARIZONA-MARICOPA CO. 7.5 min. series, orthophotoquad. U. S. Geological Survey.

PHOENIX, ARIZONA. exp. ed. space photomap. 1:250,000. U. S. Geological Survey, 1969.

PHOENIX, ARIZONA. rev. ed. topographic 1:250,000. U. S. Geological Survey, 1969.

PORTRAIT U.S.A. color composite map. National Geographic Society.

Teacher References

Avery, Eugene T. 1977. *Interpretation of Aerial Photographs.* 3rd ed. Minneapolis, MN: Burgess Publishing Co.

Boyer, Robert E. 1971. *How to Study Earth from Space.* Washington, DC: National Science Teachers Association.

__________. 1973. Remote sensing of earth: A new perspective. *The Science Teacher* 40(Oct.): 32-39.

Corliss, William R. 1971. *Earth Orbital Science.* Washington, DC: National Aeronautics and Space Administration.

Denny, Charles S.; Warren, Charles R.; Dow, Donald H.; and Dale, William J. 1968. *A Descriptive Catalog of Selected Aerial Photographs of Geologic Features in the United States.* Professional Paper 590. Washington, DC: U. S. Geological Survey.

Earth Science Curriculum Project. 1968. *Stereo Atlas.* Northbrook, IL: Hubbard Scientific Co.

Fisher, John J. 1977. Teaching geologic earth science remote sensing at the collegiate and the secondary school level. *Journal of Geological Education* 25(1): 2-14.

Snobble, John K. 1970. *Stereoscopic Aerial Photographs for Earth Science.* Morristown, NJ: Silver Burdett Co.

U. S. Forest Service. 1969. *Foresters' Guide to Aerial Photo Interpretation.* Handbook No. 308. Washington, DC: U. S. Dept. of Agriculture.

U. S. Geological Survey. 1971. *Aerial Photographic Reproductions.* Washington, DC: U. S. Government Printing Office.

———. 1971. *Studying the Earth from Space.* Washington, DC: U. S. Government Printing Office.

———. 1975. *The EROS Data Center.* Washington, DC: U. S. Government Printing Office.

Wanless, Harold R. 1969. *Aerial Atlas.* Northbrook, IL: Hubbard Scientific Co.

Warren, Charles R.; Schmidt, Dwight L.; Denny, Charles S.; and Dale, William J. 1969. *A Descriptive Catalog of Selected Aerial Photographs of Geologic Features in Areas Outside the United States.* Professional Paper No. 591. Washington, DC: U. S. Geological Survey.

Unit 2

Meteorology

The atmosphere which covers the surface of our planet affects students every day. The clothes we wear and our daily activities are governed to some degree by the activities of the blanket of air which surrounds us.

Programs 6 through 14 cover the basic rules and activities of the atmosphere in a sequence of carefully planned segments designed to lead the student to an understanding of the functioning of the atmosphere that we call weather. It also introduces the student to job opportunities, possible future hobbies, and safety precautions for violent storms.

The first program capitalizes on concepts learned in life science by explaining how the interrelationships of the plant and animal communities are similar to the basic cycles of the atmosphere. Programs 7 and 8 explore the energy systems of the atmosphere, the theory of air masses, cloud formation, and precipitation. Programs 10 and 11 pull together the concepts developed in earlier programs to present and illustrate storm theory. Programs 12, 13, and 14 investigate the process of regional and national forecasting and consider long term weather patterns.

Throughout the weather sequence, scattered segments raise questions about air quality, chronicle the lives of famous atmospheric scientists, and introduce amateur weather observers. A special segment in this unit looks at snow as a unique and aesthetic phenomenon, allowing students from coastal regions to experience snow as it occurs in mountain counties.

References

BOOKS

Donn, William L. 1951. *Meteorology with Marine Applications*. 2nd ed. New York: McGraw-Hill Book Co.

Federal Aviation Administration, and National Oceanic and Atmospheric Administration. 1975. *Aviation Weather: For Pilots and Flight Operations Personnel*. rev. ed. Washington, DC: Aviation Maintenance Foundation.

Miller, Albert, and Thompson, Jack C. 1970. *Elements of Meteorology*. 2nd ed. Columbus, OH: Charles E. Merrill Co.

Neuberger, Hans, and Nicholas, George. 1962. *Manual of Lecture Demonstrations, Laboratory Experiments, and Observational Equipment for Teaching Elementary Meteorology in Schools and College*. University Park, PA: Pennsylvania State Univ.

Science Associates, Inc. *Catalog*. P. O. Box 230, 230 Nassau Street, Princeton, NJ 08540

Sloane, Eric. 1952. *Eric Sloane's Weather Book*. New York: Hawthorn Books, Inc.

Trowbridge, Leslie W. 1973. *Experiments in Meteorology: Investigations for the Amateur Scientist*. Garden City, NY: Doubleday and Co., Inc.

PERIODICALS

BULLETIN. American Meteorological Society, monthly.

NATIONAL WEATHER DIGEST. National Weather Association, bimonthly.

NOAA JOURNAL. quarterly.

WEATHERWISE. bimonthly.

6

Our Ocean of Air

Cycles and the Atmosphere
Why Do People Make Dirty Air?
The Structure of the Atmosphere
Radiosondes Watch the
Upper Atmosphere

Program Overview

OUR OCEAN OF AIR is the first of nine programs dealing with meteorology, climatology, and air pollution. The program begins with an interview with a botanist who helps students relate atmospheric functions to the living world. Next, a very short segment introduces the concept of air pollution by describing clean air. Segment Three examines the structure of the atmosphere and considers some of the phenomena present in each zone. RADIOSONDES WATCH THE UPPER ATMOSPHERE records the launch and recovery of a radiosonde instrument package and describes how this instrument is used to gather data.

Textbook References

- A SEARCH FOR UNDERSTANDING
    Ch. 14-1: The Nature of the Atmosphere, pp. 454-462
    Ch. 14-2: Pressure, Density and Height of the Atmosphere, pp. 463-468
    Ch. 14-3: The Layers of the Atmosphere, pp. 468-471
- MODERN EARTH SCIENCE
    Ch. 20: Air and Its Movements, pp. 420-438
- PATTERNS IN OUR ENVIRONMENT
    Ch. 2-8: Can People Affect the Temperature of the Entire Earth?, pp. 38-41
- THE WORLD WE LIVE IN
    Ch. 33: The Atmosphere and Solar Radiation, pp. 496-514
- EARTH SCIENCE: A LABORATORY APPROACH
    No references
- EARTH SCIENCE: IIS
    Idea 5-1: It's Hard to Believe, pp. 161-164
    Idea 5-2: The Pressure's On, pp. 165-170
- FOCUS ON EARTH SCIENCE
    Ch. 9-1: The Atmosphere of the Earth, pp. 160-161
    Ch. 9-2: Air Pressure, pp. 161-162
    Ch. 9-3: Composition of the Atmosphere, pp. 163-164
    Ch. 9-4: Structure of the Atmosphere, pp. 165-168
- HOLT: EARTH SCIENCE
    Ch. 9: Air, pp. 244-275
- INVESTIGATING THE EARTH
    Ch. 5: Water in the Air, pp. 101-107
- OUR ENVIRONMENT IN SPACE
    No references
- PATHWAYS IN SCIENCE
    IV Ch. 1: The Atmosphere is an Ocean of Air, pp. 183-188

Student Readings

Calder, Nigel. *The Weather Machine.* New York: Viking Press, Inc., 1975.

Craig, Richard A. *The Edge of Space--Exploring the Upper Atmosphere.* Garden City, NY: Doubleday and Co., Inc., 1968.

Dobson, Gordon M. *Exploring the Atmosphere.* 2nd ed. New York: Oxford Univ. Press, 1968.

Federal Aviation Administration. *Pilots Handbook of Aeronautical Knowledge.* Washington, DC: U. S. Government Printing Office, 1971.

Kotsch, William J. *Weather for the Mariner.* Annapolis, MD: U. S. Naval Institute Press, 1977.

Lehr, Paul E., R. Will Burnett, and Herbert S. Zim. *Weather: Air Masses, Clouds, Rainfall, Storms, Weather Maps, Climate.* New York: Simon and Schuster, 1957.

Maunder, W. J. *The Value of Weather.* New York: Barnes and Noble, 1970.

Rosenfeld, Sam. *Science Experiments with Air.* New York: Harvey House, Inc., 1969.

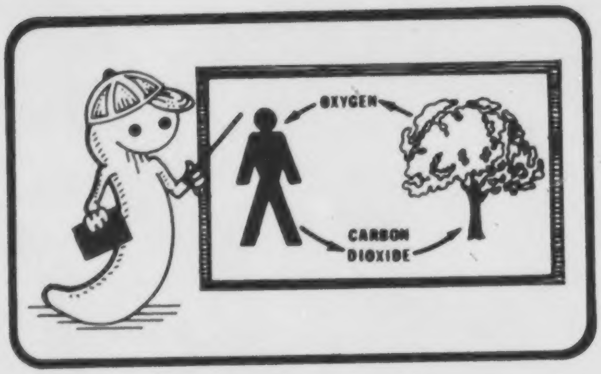
Simon, Seymour. *Projects with Air.* New York: Franklin Watts, Inc., 1975.

Sloane, Eric. *Eric Sloane's Weather Library.* 3 vols. New York: Meredith Press, 1963.

Sutton, Oliver G. *The Challenge of the Atmosphere.* Riverside, CT: Greenwood Press, 1961.

Thompson, Philip D., and Robert O'Brian. *Weather.* New York: Silver Burdett Co., 1968. (a title in the LIFE Science Library)

6-1



Cycles and the Atmosphere

Segment Synopsis

In CYCLES AND THE ATMOSPHERE, Dr. Richie Bell, Director of the North Carolina Botanical Gardens, elaborates on students' knowledge of the life sciences as he describes how plant life processes are related to weather phenomena. He traces the cycles that tie the atmosphere to living plants, paying special attention to the oxygen-carbon dioxide, hydrologic, and nitrogen cycles. He explains that man often interfers knowingly and unknowingly with the cycles and suggests ways in which students might help ease the resulting problems.

Concepts

- Living organisms are part of long term natural cyclic processes in the atmosphere. These processes circulate compounds throughout the atmosphere.
- Man's activities often interrupt or modify natural cycles within the atmosphere.
- The interruption of natural atmospheric cycles may have catastrophic consequences for the community of living things.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- describe and explain how the oxygen-carbon dioxide, nitrogen, and hydrologic cycles operate
- give examples of the effects of people's activities on each of the major natural cycles.

Learning Activities

Have students write a description of the atmosphere and how it affects them. (Hold the papers and compare the descriptions with those written for Program 14).

Introduce the following terms: cycle, carbon dioxide cycle, hydrologic cycle, nitrogen cycle, air pollution.

Have students prepare bulletin board displays illustrating the hydrologic, carbon dioxide, and nitrogen cycle.

Media Resources

FILMS

THE EARTH: ITS WATER CYCLE. 16mm. 10 1/2 min. sd. color. Coronet Films.

THE WATER CYCLE. 16mm. 11 min. sd. b and w. Ency. Britannica Ed. Corp.

WATERS RETURNING. 16mm. 6 min. sd. color. Macmillan Films.

FILM LOOPS

HYDROLOGY SERIES. 12 color film loops. Bailey Film Associates.

SLIDES

THE HYDROLOGIC CYCLE. 15 color slides. Ward's Natural Science Establishment, Inc.

TRANSPARENCIES

THE HYDROLOGY CYCLE. 1 color transparency. Hammond, Inc.

METEOROLOGY SET. 27 transparencies. Ward's Natural Science Establishment, Inc.

WATER CYCLE. 1 color transparency. Hubbard Scientific Co.

MODEL

WATER CYCLE MODEL. 12" x 16" x 3" plastic model. Earth Science Materials.

Teacher References

Conway, H. McKinley, and Liston, Linda L. 1974. *The Weather Handbook.* Atlanta: Conway Research, Inc.

Exline, Joseph D. 1975. *Individualized Techniques for Teaching Earth Science.* Englewood Cliffs, NJ: Prentice-Hall, Inc.

Huschke, Ralph E., ed. 1959. *Glossary of Meteorology.* Boston: American Meterological Society.

Leopold, Luna B. 1974. *Water: A Primer.* San Francisco: W. H. Freeman and Co.

National Oceanic and Atmospheric Administration. 1974. *The Hydrologic Cycle.* Washington, DC: U. S. Government Printing Office.

Revelles, Roger. 1963. Water. *Scientific American* 209 (Sept.): 92-100.

Strahler, Arthur N. 1971. *The Earth Sciences.* 2nd ed. New York: Harper and Row.

U. S. Air Force. 1974. *Weather for Air Crews.* Washington, DC: U. S. Government Printing Office.

6-2

DIRTY
AIR-
UGH!!

Why Do People Make Dirty Air?

Segment Synopsis

A little girl asks her father what clean air looks like. The images he describes cause her to ask why people make dirty air. This very short segment on air pollution reminds students that nature "makes" clean air; people produce dirty air.

Concept

- Man's activities often result in pollution of the atmosphere.

Objective

After watching this segment and completing appropriate follow-up activities, the student should be able to

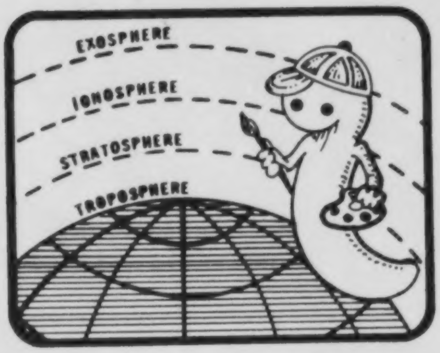
- explain the difference between clean and polluted air.

Learning Activity

This aesthetic segment might be used to inspire students to express their feelings about clean air and air pollution in some form, such as a poem, song, or picture.

6-3

The Structure of the Atmosphere



Segment Synopsis

This segment introduces students to the vaguely layered structure of the atmosphere. It explains how each layer was discovered and describes the properties of each. Rare film footage shot in Alaska, shows the spectacular aurora borealis.

Concepts

- The atmosphere is a vaguely structured mixture of gases.
- The atmosphere can be divided into layers based on the kinds of phenomena which occur at various altitudes.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- outline and describe the structure of the atmosphere
- describe phenomena which typically occur in the troposphere, stratosphere, ionosphere, and exosphere.

Learning Activity

Introduce students to the following terms: troposphere, tropopause, stratosphere, stratopause, ionosphere, exosphere, aurora borealis, ozone, cosmic rays, weather.

Media Resources

FILM

RESEARCH IN THE ATMOSPHERE. 16mm. 25 min. sd. color. National Aeronautics and Space Administration, 1969.

FILM LOOPS

LEARNING ABOUT AIR. 4 color film loops. 2 disc recordings. Society for Visual Education.

TRANSPARENCIES

METEOROLOGY SET. 27 transparencies. Ward's Natural Science Establishment, Inc.

POSTER

THE UPPER ATMOSPHERE. NWRF 26-0665-106. Dept. of the Navy, Weather Research Facility.

Teacher References

Anthes, Richard, et al. 1975. *The Atmosphere.* Columbus, OH: Charles E. Merrill Co.

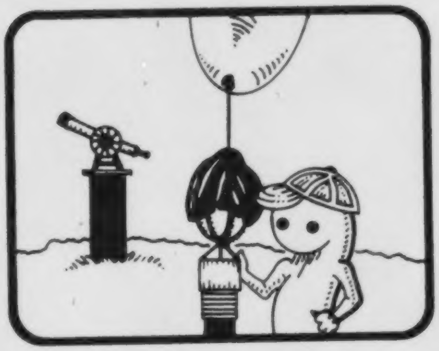
Corliss, William R., 1968. *Space Radiation.* Washington, DC: U. S. Atomic Energy Commission.

Goody, Richard, and Walker, James C. 1972. *Atmospheres.* Engelwood Cliffs, NJ: Prentice-Hall, Inc.

Wright, Sir Charles. 1962. The Antartic and the upper atmosphere. *Scientific American* 207 (Sept.): 74-83.

6-4

Radiosondes Watch the Upper Atmosphere



Segment Synopsis

Small and relatively inexpensive instrument packages called radiosondes are launched twice daily at many of the National Weather Service Offices in the United States. Many students find the radiosonde a fascinating instrument because it combines weather measurements with space-age telemetry. This segment follows the launch and recovery of an instrument at Cape Hatteras. Students have an opportunity to observe the techniques used to measure the properties of the upper atmosphere and discover some of the problems involved in the use of radiosondes.

Concept

- Instruments are used to measure the properties of the atmosphere.

Objective

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain how various types of meteorological instruments operate and what properties of the atmosphere they measure.

Learning Activity

Have students learn the basic parts of a radiosonde--e.g., balloon, parachute, radio transmitter, barometer, thermometer, and hygrometer.

Media Resources

POSTERS

THE UPPER ATMOSPHERE. NWRF 26-0665-106. Dept. of the Navy, Weather Research Facility.

WEATHER BALLOONS....THEIR USE IN THE UPPER AIR OBSERVATIONAL PROGRAM. Washington, DC: U. S. Government Printing Office.

Teacher References

National Weather Service. 1970. *Observing Handbook No. 2 Substation Observations.* Silver Spring, MD: National Oceanic and Atmospheric Administration.

__________. 1976. *A Radiosonde, What Is It?* Washington, DC: U. S. Government Printing Office. (pamphlet)

7

Heat and Circulation

Insolation and the Greenhouse Effect
Weather as a Hobby
Edmund Halley
Wind Belts and Circulation

Program Overview

The sun supplies energy to the earth in the form of light. That energy is responsible for all of the weather phenomena taking place in our atmosphere. INSOLATION AND THE GREENHOUSE EFFECT identifies how the sun's energy drives our atmosphere through insolation, absorption, and the conversion of light to heat energy. Later, global circulation, coriolis, and wind belts are studied. In Segment Two, WEATHER AS A HOBBY, Ed Maddox describes his activities as a volunteer climatic observer for the National Weather Service. The third segment features the famous scientist, Edmund Halley, and shows his many discoveries and achievements.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 14-4: Heating the Atmosphere, pp. 472-475
  - Ch. 15-1: Temperatures, pp. 477-482
  - Ch. 15-2: Air Pressure, pp. 482-489
  - Ch. 16-2: Sunshine Patterns, pp. 523-531
  - Ch. 16-3: Wind Patterns, pp. 531-534
- MODERN EARTH SCIENCE
  - Ch. 20: Air and Its Movements, pp. 420-438
- PATTERNS IN OUR ENVIRONMENT
  - Ch. 4-1: The Radiometer, p. 80
  - Ch. 4-2: The Brightness and Temperature of a Light, p.80
  - Ch. 4-4: A Temperature Pattern, p. 85
- THE WORLD WE LIVE IN
  - Ch. 33: The Atmosphere and Solar Radiation, pp. 496-514
  - Ch. 34: Atmospheric Pressure and Winds, pp. 515-529
  - Ch. 35: General Circulation of the Atmosphere, pp. 530-541
- EARTH SCIENCE: A LABORATORY APPROACH
  - Ch. 9-5: Forces and Motion in the Atmosphere, pp. 197-199
  - Ch. 9-6: The Daily Cycle of Atmospheric Change, pp. 199-203
  - Ch. 9-8: The Atmosphere and Light, pp. 205-208
- EARTH SCIENCE--IIS
  - Idea 2-2: You are the Sunshine of My Life, pp. 43-49
  - Idea 2-3: Sunshine On My Shoulder, pp. 49-53
  - Idea 5-7: Bottoms Up, pp. 189-194
- FOCUS ON EARTH SCIENCE
  - Ch. 9-5: Heat, pp. 169-172
  - Ch. 9-6: Seasons, pp. 173-180
  - Ch. 10-1: Air Circulation, pp. 182-184
  - Ch. 10-2: Major Wind Systems, pp. 185-187

- HOLT: EARTH SCIENCE
  Ch. 9: Air, pp. 244-275
- INVESTIGATING THE EARTH
  Ch. 6: Energy and Wind, pp. 121-140
- OUR ENVIRONMENT IN SPACE
  Ch. 11: Energy Exchanges by Atmospheric Circulation, pp. 227-239
  Ch. 12: Exchanges of Heat Energy on Land and Sea, pp. 241-258
- PATHWAYS IN SCIENCE
  IV Ch. 2: The Air Exerts Pressure, pp. 189-194
  IV Ch. 3: How We Measure Air Pressure, pp. 195-200
  IV Ch. 4: Air Pressure Goes to Work, pp. 201-207
  IV Ch. 5: The Earth's Heat Comes from the Sun, pp. 208-213
  IV Ch. 6: The Temperature of the Atmosphere Keeps Changing, pp. 214-220
  IV Ch. 7: The Blowing Winds, pp. 221-226

Student Readings

American Meteorological Society. *The Challenge of Meteorology.* Boston: American Meteorological Society, 1977.

Kals, W. S. *The Riddle of the Winds.* Garden City, NY: Doubleday and Co., Inc., 1977.

Reiter, Elmar R. *Jet-Streams: How Do They Affect Our Weather?* Garden City, NY: Doubleday and Co., Inc., 1967.

Rue, E. Aubert de la, *Man and the Winds.* New York: Philosophical Library, 1955.

Stone, A. Harris, and Herbert Spiegel. *The Winds of Weather.* Englewood Cliffs, NJ: Prentice-Hall, Inc., 1969.

Insolation and the Greenhouse Effect

Segment Synopsis

INSOLATION AND THE GREENHOUSE EFFECT explores the relationship of sunlight and clouds to temperature. It begins by examining the way sunlight is scattered and absorbed as it passes through the atmosphere on a clear and a cloudy day. It shows how light is converted to heat energy by various soil colors and uses a greenhouse to illustrate how solar energy can be trapped near the earth by clouds. A pyroheliometer is used to measure the sun's energy on a cloudless day. Students observe how temperature varies from a clear day to an overcast day.

Concepts

- Most of our energy comes from the sun.
- Energy from the sun is responsible for many fundamental processes on earth.
- Sunlight is partially absorbed and scattered as it passes through the atmosphere.
- The temperature near the earth is related to the amount of solar radiation striking the surface.
- The amount of solar (light) energy that can be absorbed and converted to heat energy in a soil depends on the soil's color.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain how light is affected as it passes through the atmosphere
- demonstrate the different amounts of light energy converted to heat by light and dark colored objects
- explain the greenhouse effect
- explain how the air temperature may respond to variations in solar energy and cloud cover (insolation curves).

Learning Activities

Introduce students to terms such as absorption, reflection, insolation, radiant energy, heat energy and scattering.

Have students photograph examples of applications of the greenhouse effect.

Have students invite a greenhouse operator to tell the class what he uses the greenhouse for and how he controls its temperature.

Take students on a tour of a greenhouse or solar home.

Have students prepare displays illustrating the application of solar energy to home heating.

Media Resources

FILMS

ABOVE THE HORIZON. 16mm. 21 min. sd. color. Modern Learning Aids, 1969.

SOLAR ENERGY: TO CAPTURE THE POWER OF SUN AND TIDE. 16mm. 24 min. sd. color. ACI Films, Inc., 1975.

SOLAR RADIATION I: SUN AND EARTH. 16mm. 18 min. sd. color. Modern Learning Aids.

SOLAR RADIATION II: THE EARTH'S ATMOSPHERE. 16mm. 20 min. sd. color. Modern Learning Aids.

WHY SEASONS CHANGE. 16mm. 11 min. sd. b and w. Ency. Britannica Ed. Corp.

FILM LOOPS

INVESTIGATIONS IN SCIENCE: METEOROLOGY SERIES. 5 color film loops. Bailey-Film Associates.

TRANSPARENCIES

METEOROLOGY SET. 27 transparencies. Ward's Natural Science Establishment, Inc.

MAPS

THE NATIONAL ATLAS OF THE UNITED STATES. U. S. Geological Survey. Washington, DC: U. S. Government Printing Office.

Teacher Reference

U. S. Geological Survey. 1971. Solar radiation. *The Science Teacher* 38 (9): 28-29.

7-2

Weather as a Hobby

Segment Synopsis

Edwin Maddox, a textile mill foreman from Sanford, North Carolina, observes the weather as a hobby. In this interview he describes his hobby and his participation in the National Climatic Observer Network operated by the National Weather Service. He shows the equipment he uses and how it works and he explains the reports he submits concerning unusual weather conditions. Mr. Maddox typifies the people who volunteer their time and effort to furnish the National Weather Service with a more complete record of weather conditions which the Service can use in study and research.

Concepts

- Instruments are used to measure the properties of the atmosphere.
- To understand the overall behavior of the atmosphere and its condition at any given time, many observations must be made at various locations in the area.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain the necessity for many observations of weather at various locations in formulating an overall understanding of the weather
- explain what volunteer climatic observers do.

Learning Activity

This segment is intended simply to introduce the idea of observing weather as a hobby. You may wish to contact the nearest Weather Service office and locate a hobbist or cooperative observer to visit with your class.

7-3

Edmund Halley

Segment Synopsis

This segment chronicles the life of Edmund Halley who lived from 1656 to 1742. Halley typifies the multi-facetted scientists who lived and worked during the 17th and 18th centuries. The show summarizes several of Halley's more important efforts, such as his discovery of the well-known comet, speculations concerning the saltiness of the oceans, studies of air pressure influenced by altitude, and compilation of mortality rates. Edmund Halley is seen as an individual of varied interests. His discoveries of wind belts and global air circulation are only two of many contributions he made to our fund of knowledge.

Concepts

- Because the atmosphere follows the laws of nature, its behavior can be predicted.
- Man's mind is his most important tool for investigating the earth.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- describe the procedures Edmund Halley used to investigate the earth
- summarize Halley's reasoning of global circulation which lead to his theory of wind belts.

Learning Activity

This biographical segment is intended to complement the segment on wind belts and circulation. You may wish to have students prepare a display illustrating some of the highlights of Halley's life.

7-4

Wind Belts and Circulation

Segment Synopsis

Why do winds blow in large belts about the earth? How is energy moved from the equator toward the poles? What causes winds in the northern hemisphere to turn to the right? How does the process of convection help drive the wind belts? What is the jet stream? This segment explores global circulation and the mechanisms which move energy from the equatorial regions toward the North and South Poles. It illustrates these basic concepts of circulation using simple graphics.

Concepts

- Movement of air is caused by heating and cooling.
- The unequal distribution of solar energy produces the general circulation in the atmosphere.
- Convection produces the basic circulation of the air.
- The earth's rotation modifies basic circulation by deflecting the N-S winds and produces wind belts
- Air masses, moving under the influence of the wind belts, transfer energy from one place to another near the surface of the earth.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain and give examples of the way air is moved by convection
- explain the general pattern of air circulation in the atmosphere
- demonstrate how the earth's rotation creates the wind belts.

Learning Activity

Introduce students to the following terms: coriolis, convection, doldrums, trade winds, latitudes, westerlies, polar easterlies.

Media Resources

FILMS

THE ATMOSPHERE IN MOTION. 16mm. 20 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

PLANETARY CIRCULATION. 16mm. 25 min. sd. color. Modern Learning Aids, 1969.

THE RESTLESS OCEAN OF AIR. 16mm. 20 min. sd. color. Prism Productions, 1969.

FILM LOOPS

ATMOSPHERIC CIRCULATION PARTS I AND II. 2 color film loops. Hubbard Scientific Co.

CORIOLIS EFFECT. 1 color film loop. Hubbard Scientific Co.

INVESTIGATIONS IN SCIENCE: METEOROLOGY SERIES. 5 color film loops. Bailey-Film Associates.

TEMPERATURE, PRESSURE, AND WIND PARTS I AND II. 2 color film loops. Hubbard Scientific Co.

STUDY PRINTS

WEATHER PRINTS. 12 9" x 15" color prints. Hubbard Scientific Co.

TRANSPARENCIES

METEOROLOGY SET. 27 transparencies. Ward's Natural Science Establishment, Inc.

POSTER

THE UPPER ATMOSPHERE. NWRF 26-0665-106. Dept. of the Navy, Weather Research Facility.

Teacher References

Beer, Tom. 1974. *Atmospheric Waves*. New York: John Wiley and Sons, Inc.

McDonald, James E. 1952. The coriolis effect. *Scientific American* 186(May): 72-76.

Palmen, Eric H., and Newton, Chester W. 1969. *Atmospheric Circulation Systems: Their Structure and Physical Interpretations*. New York: Academic Press.

Riehl, Herbert. 1962. *Jet Streams of the Atmosphere*. Technical Report No. 32. Department of Atmospheric Science. Fort Collins, CO: Colorado State Univ.

Rubin, M. J. 1962. The Antartic and the weather. *Scientific American* 207(Sept.): 84-94.

Starr, Victor P. 1956. The general circulation of the atmosphere. *Scientific American* 195(Dec.): 40-45.

Stewart, R. W. 1969. The atmosphere and the ocean. *Scientific American* 221(Sept.): 76-86.

8

Winds, Weather, and Air Masses

Local Breezes
Folklore and the Weather
The Origin of Air Masses

Program Overview

This program continues the theme of Program Seven. It studies insolation, conversion of light energy to heat energy, and convection on a local basis. LOCAL BREEZES examines how energy is transferred to form land-sea and mountain-valley breezes. In FOLKLORE AND THE WEATHER, a TV weather man and an old mountain farmer explore the idea that weather phenomena provide signs of their coming which have been interpreted in folklore over the years. The final segment returns to the movement of energy. Dan Salgado, National Weather Service Meteorologist, explains how air masses form, how they move by global wind belts, and what happens when two air masses meet.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 15-2: Air Pressure, pp. 482-489
  - Ch. 15-4: Air Masses and Thunderstorms, pp. 493-499
- MODERN EARTH SCIENCE
  - Ch. 20: Air and Its Movements, pp. 420-438
  - Ch. 22: Weather, pp. 457-478
- PATTERNS IN OUR ENVIRONMENT
  - Ch. 7-1: Heavy and Light Air, pp. 174-176
  - Ch. 7-10: A Micro Weather Box, pp. 203-204
  - Ch. 7-11: Land and Water Temperatures, pp. 204-205
- THE WORLD WE LIVE IN
  - Ch. 35: General Circulation of the Atmosphere, pp. 530-541
  - Ch. 38: Air Masses and Fronts, pp. 569-580
- EARTH SCIENCE: A LABORATORY APPROACH
  - Ch. 9-6: The Daily Cycle of Atmospheric Change, pp. 199-203
  - Ch. 9-7: Moisture as a Factor in Atmospheric Change, pp. 204-205
  - Ch. 9-10: The Contact Region Between Two Air Masses, pp. 209-211
- EARTH SCIENCE: IIS
  - Idea 5-4: It Whistles Through the Trees, pp. 177-180
- FOCUS ON EARTH SCIENCE
  - Ch. 10-1: Air Circulation, pp. 182-184
- HOLT: EARTH SCIENCE
  - Ch. 9: Air, pp. 244-275
  - Ch. 10: Weather, pp. 276-312
- INVESTIGATING THE EARTH
  - Ch. 6: Energy and Wind, pp. 121-140

- OUR ENVIRONMENT IN SPACE
  Ch. 12: Exchanges of Heat Energy on Land and Sea, pp. 241-258

- PATHWAYS IN SCIENCE
  IV Ch. 7: The Blowing Winds, pp. 221-226
  V Ch. 3: Air Masses and Fronts, pp. 260-265

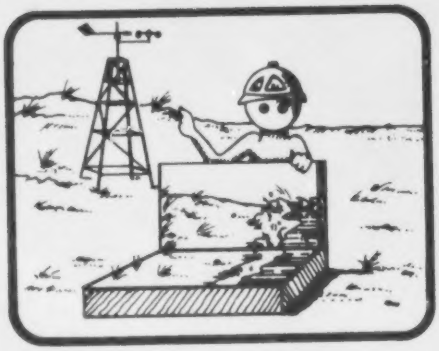
Student Readings

Davis, Albert. *A January Thaw Will Freeze a Hog and Other Weather Folklore.* New York: Crown Publishers, Inc., 1977.

Edinger, James G. *Watching for the Wind: The Seen and Unseen Influences on Local Weather.* Garden City, NY: Doubleday and Co., Inc., 1967.

Kals, W. S. *The Riddle of the Winds.* Garden City, NY: Doubleday and Co., Inc., 1977.

Lee, Albert. *Weather Wisdom: Being an Illustrated Practical Volume Wherein is Contained Unique Compilation and Analysis of the Facts and Folklore of Natural Weather Prediction.* Garden City, NY: Doubleday and Co., Inc., 1976.



Local Breezes

Segment Synopsis

LOCAL BREEZES takes a look at the energy transferred by the winds on a local scale. It demonstrates that the air over land heats at a different rate from the air over water. Land-sea breezes along a beach on the Outer Banks are studied and the area's air temperature and pressure measured from sunrise calm throughout a typical day. Mountain valley breezes are observed in a similar manner. The segment concludes by asking students if they think a city might create its own local breezes.

Concepts

- The unequal absorption of solar energy produces local temperature differences.
- Convection produces the basic circulation of the air.
- Cumuloform clouds, producing showery precipitation, result from small scale convection.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- demonstrate how the character of a surface affects its light absorbing properties
- demonstrate how air is moved by convection
- explain what local winds are and how they are caused.

Learning Activity

Review the concepts students have learned concerning insolation, absorption, reflection, and convection.

Media Resources

FILMS

OUR RESTLESS OCEAN OF AIR. 16mm. 20 min. sd. color. Prism Productions, 1969.

WHAT MAKES THE WIND BLOW. 16mm. 16 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

FILM LOOPS

TEMPERATURE, PRESSURE, AND WIND PARTS I AND II. 2 color film loops. Hubbard Scientific Co.

TRANSPARENCIES

METEOROLOGY SET. 27 transparencies. Ward's Natural Science Establishment, Inc.

Teacher References

National Weather Service. 1973. *Cloud Code Chart.* Washington, DC: U. S. Government Printing Office.

___________. 1976. *Clouds.* Washington, DC: U. S. Government Printing Office. (chart)

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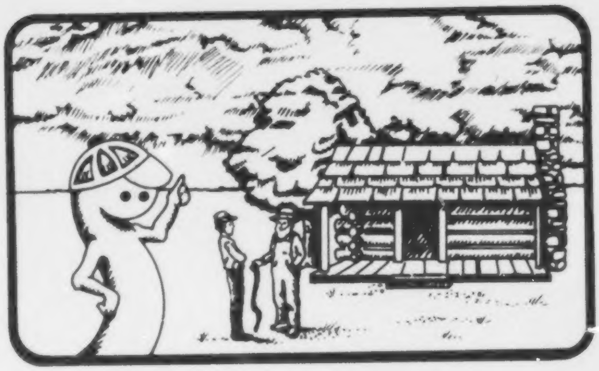

Folklore and the Weather

Segment Synopsis

Meteorologist, Chick Carney, lost and looking for the golf course, asks an old farmer, played by Bill Alspaugh, for directions. Before the conversation ends, Chick has explained the scientific basis for a number of common folk sayings and tales about the weather. The sayings include: "Mare's tails and mackerel skies proceed a rain;" "Red sky at dawning, sailors take warning;" and "Ring around the moon, rain soon."

Concepts

- Because the atmosphere follows the laws of nature, its behavior can be predicted.
- Commonly recognized atmospheric phenomena create observable weather features.
- Man's senses are used to make observations; his mindto interpret observations.

Objective

After watching this segment and completing appropriate follow-up activities the student should be able to

- relate commonly seen weather phenomena to the conditions they indicate.

Learning Activity

This segment is intended as an interest stimulator and as a result you may wish to limit your preparatory activities to asking students if they know any folk tales or folklore concerning the weather.

Teacher References

Garriott, Edward B. 1971. *Weather Folklore and Local Weather Signs.* Reprint of 1903 ed. Detroit: Gale Research Co.

Inwards, Richard. 1971. *Weather Lore.* Ed. E. L. Hawks. Reprint of 1950 ed. New York: Barnes and Noble.

Smith, Elmer L., compiler. *Weather Lore and Legend.* Lebanon: PA: Applied Arts Publisher.

Swainson, C. 1974. *A Handbook of Weather Folklore.* Reprint of 1873 ed. Detroit: Gale Research Co.

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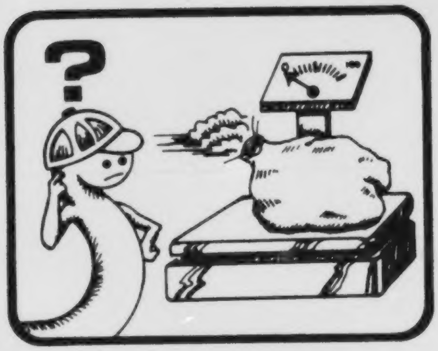


The Origin of Air Masses

Segment Synopsis

Dan Salgado, meteorologist at the Raleigh-Durham Forecast Office of the National Weather Service, explains what an air mass is, how it moves and affects the area into which it moves, and how the collision of two air masses creates weather phenomena. He also classifies air masses and discusses how seasonal changes in air mass locations affect the weather.

Concepts

- Air masses are large units or bodies of air with relatively uniform properties.
- Air masses, influenced by wind belts, move energy from one place to another along the surface of the earth.
- When the dissimilar air masses meet, interaction along their interface may result in formation of a storm system.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain how air masses form and behave over time
- explain how air masses interact to form fronts
- explain how air masses help move energy from the equator to the poles.

Learning Activity

Introduce students to the following terms: air mass, marine air mass, continental air mass, tropical air mass, polar air mass, front, jet stream.

Media Resources

FILMS

AIR MASSES AND FRONTS--AIR MASSES. 16mm. 12 min. sd. color. U. S. Air Force, 1962.

AIR MASSES AND FRONTS--THE COLD FRONT. 16mm 9 min. sd. color. U. S. Air Force, 1962.

AIR MASSES AND FRONTS--THE WARM FRONT. 16mm. 11 min. sd. color. U. S. Air Force, 1962.

ORIGINS OF WEATHER. 16mm. 13 min. sd. color. Ency. Britannica Ed. Corp. (produced by the National Film Board of Canada)

FILM LOOP

WEATHER FRONTS AND PRECIPITATION. 1 color film loop. Hubbard Scientific Co.

STUDY PRINTS

WEATHER. 12 9" x 15" color prints. Hubbard Scientific Co.

TRANSPARENCIES

METEOROLOGY SET. 27 transparencies. Ward's Natural Science Establishment, Inc.

WARM AND COLD FRONT. 1 color transparency. Hubbard Scientific Co.

Teacher Reference

Federal Aviation Administration. 1971. *Pilots Handbook of Aeronautical Knowledge*. Washington, DC: U. S. Government Printing Office.

9

Clouds and Precipitation

Adiabatic Cooling and Clouds
Temperature, Altitude, and Precipitation
Snow

Program Overview

Program 9 provides students with background information they need to investigate storm systems. It focuses on the symptoms of storm phenomena--clouds and precipitation. ADIABATIC COOLING AND CLOUDS explains the mechanisms which cause clouds to form. The next segment shows how temperature and altitude affects the type of precipitation that falls. SNOW takes students to mountain country where winter snows are deep and stay on the ground for weeks at a time. There they are introduced to the chilling, breath taking character of a snow environment.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 15-3: Moisture, pp. 489-492
  - Ch. 15-5: Clouds and Rain, pp. 499-507
- MODERN EARTH SCIENCE
  - Ch. 21: Water in the Atmosphere, pp. 439-456
- PATTERNS IN OUR ENVIRONMENT
  - Ch. 7-3: Water in the Atmosphere, pp. 183-184
  - Ch. 7-4: How Does a Cloud Form? pp. 184-186
- THE WORLD WE LIVE IN
  - Ch. 36: Evaporation and Condensation, pp. 542-558
  - Ch. 37: Precipitation, pp. 559-568
- EARTH SCIENCE: A LABORATORY APPROACH
  - Ch. 9-1: Clouds as Part of the Atmosphere, pp. 187-191
  - Ch. 9-2: The Temperature of the Atmosphere, pp. 191-192
  - Ch. 9-3: Moisture in the Atmosphere, pp. 193-194
  - Ch. 9-4: The Pressure of the Atmosphere, pp. 194-195
  - Ch. 9-11: Rain, Snow, Hail, and Sleet, pp. 211-213
- EARTH SCIENCE: IIS
  - Idea 5-5: Ice Cream Castles in the Air, pp. 181-184
  - Idea 5-6: Raindrops Keep Falling On My Head, pp. 185-189
- FOCUS ON EARTH SCIENCE
  - Ch. 10-4: Clouds, pp. 194-195
- HOLT: EARTH SCIENCE
  - Ch. 9: Air, pp. 244-275
  - Ch. 10: Weather, pp. 276-312
- INVESTIGATING THE EARTH
  - Ch. 5: Water in the Air, pp. 101-120
- OUR ENVIRONMENT IN SPACE
  - Ch. 13: Energy Exchanges Through Atmospheric Moisture, pp. 259-281
- PATHWAYS IN SCIENCE:
  - IV Ch. 8: The Water in Our Atmosphere, pp. 227-233

Student Readings

Battan, Louis J. *Cloud Physics and Cloud Seeding.* New York: Doubleday and Co., Inc., 1962.

Bell, Corydon. *Wonder of Snow.* New York: Hill and Wang, 1957.

Bendlich, Jeanne. *How to Make a Cloud.* New York: Parents' Magazine, 1971.

Bentley, W. A., and W. J. Humphreys. *Snow Crystals.* New York: Dover Publications, Inc., 1964.

Blanchard, Duncan C. *From Raindrops to Volcanoes, Adventures with Sea Surface Meteorology.* Garden City, NY: Doubleday and Co., Inc., 1967.

Couchman, J. Kenneth, et al. *Snow and Ice: Examining Your Environment Series.* Minneapolis, MN: Winston Press, 1972.

Mason, B. J. *Clouds, Rain and Rainmaking.* 2nd ed. New York: Cambridge Univ. Press, 1976.

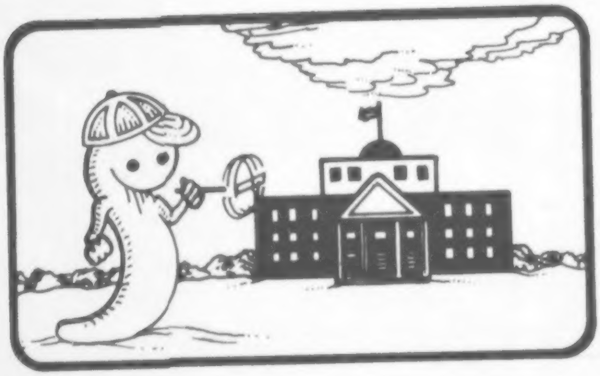
Nakaya, Ukichiro. *Snow Crystals--Natural and Artificial.* Cambridge: Harvard Univ. Press, 1954.

National Weather Service. *Clouds.* Washington, DC: U. S. Government Printing Office, 1972.

____________. *Winter Storms.* Washington, DC: National Oceanic and Atmospheric Administration, n.d. (pamphlet)

Sisson, Robert F. "Snowflakes to Keep." *National Geographic,* January, 1970, pp. 104-111.

9-1



Adiabatic Cooling and Clouds

Segment Synopsis

Why do clouds form? What materials must be present? What must the conditions be? This segment investigates each of these aspects of cloud formation. Students see a cloud created in the laboratory, learn about the process of adiabatic cooling, and apply their knowledge to determine the lowest elevation at which clouds can form on a particular day.

Concepts

- The process by which water moves on earth is known as the hydrologic cycle.
- The primary cause of condensation in the atmosphere is adiabatic cooling.
- The principle controls of evaporation include free water, surface energy, air temperature, and motion.
- Clouds are formed by moisture condensing on particles in the atmosphere.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain the hydrologic cycle
- explain adiabatic cooling
- demonstrate how a cloud forms.

Learning Activities

Introduce students to the following terms: adiabatic, condensation, nuclei, cloud base, lapse rate, precipitation.

Have students make their own clouds using a 1 gallon glass jug, hole stopper, and rubber tube. Place a short piece of glass tubing through the stopper and attach the rubber tube with a clamp. Add a small amount of water to the jug and saturate the air. Have students suck over the tube producing a vacuum. A cloud doesn't form because there are no particles in the chamber on which the water molecules may condense. Next, introduce candle smoke into the jug by releasing the vacuum tube next to the candle flame. Have students recreate the vacuum; a cloud will appear.

Have students simulate gas molecules. Mark a square on the floor and tell students to imagine it extends upward to form a cube at sea level. Give each student a styrofoam ball and have all the students move about as gas molecules. Then "raise" the cube to a higher altitude, causing some molecules to slip out of the cube as the gas expands. Compare the resulting energy at the higher altitude with that at sea level.

Media Resources

FILMS

CHANGING THE WEATHER. 16mm. 29 min. sd. color. Indiana Univ., 1968.

CLOUDS. 16mm. 9 1/2 min. sd. color. BFA Educational Media.

CLOUDS ABOVE. 16mm. 10 min. sd. color. BFA Educational Media.

CLOUDS OF THE HEMISPHERE. 16mm. 8 min. sd. color. Macmillan Films.

FORMATION OF RAINDROPS. 16mm. 26 min. sd. color. Modern Learning Aids.

WHAT MAKES CLOUDS. 16mm. 19 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

WHAT MAKES RAIN. 16mm. 22 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

FILM LOOPS

CLOUD FORMATION. 1 color film loop. Hubbard Scientific Co.

CLOUDS. 1 color film loop. Doubleday and Co., Inc., 1970.

EVAPORATION & CONDENSATION. 1 color film loop. Hubbard Scientific Co.

INVESTIGATIONS IN SCIENCE: METEOROLOGY SERIES. 5 color film loops. Bailey-Film Associates.

LABORATORY NUCLEATION OF SUPERCOOLED CLOUDS AND CONDENSATION NUCLEI. 2 b and w film loops. Modern Learning Aids.

SLIDES

CLIMATE AND CLOUDS. 20 color slides. Society for Visual Education.

METEOROLOGY VIEW FILES. 2 sets of 15 color slides each. Hubbard Scientific Co.

WHAT ON EARTH? SLIDE SET M/19/1.

TRANSPARENCIES

CLOUD TYPES. 1 color transparency. Hammond, Inc.

CLOUD TYPES. 2 color transparencies. Hubbard Scientific Co.

METEOROLOGY SET. 27 transparencies. Ward's Natural Science Establishment, Inc.

POSTERS

CLOUD CHART. P. O. Box 8615, Richmond, Virginia 23226.

CLOUD CODE CHART. National Oceanic and Atmospheric Administration.

Teacher References

Battan, Louis J. 1962. *Cloud Physics and Cloud Seeding*. New York: Doubleday and Co., Inc.

Myers, Joel N. 1968. Fog. *Scientific American* 219(Dec.): 74-82.

Roberts, Walter Orr. 1957. Sun clouds and rain clouds. *Scientific American* 196(April): 138-140.

Scorer, Richard. 1972. *Clouds of the World: A Complete Color Encyclopaedia* North Pomfret, VT: David and Charles, Inc.

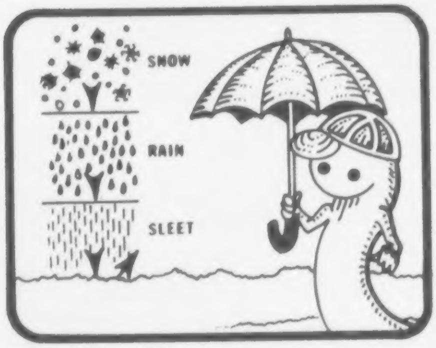
Tricker, R.A.R. 1970. *The Science of Clouds*. New York: American Elsevier Publishing Co.

Woodcock, A. H. 1957. Salt and rain. *Scientific American*. 197(Oct.): 42-47.

World Meteorological Organization, 1956. *International Cloud Atlas*. 3 vols., Geneva, Switzerland.

9-2

Temperature, Altitude, and Precipitation



Segment Synopsis

This segment illustrates how altitude temperature affects the kind of precipitation that falls to earth. Simple graphics, film, and animation are used to show why water condenses to form rain, snow, sleet, freezing rain, and hail under various conditions as it falls to earth.

Concepts

- The type of clouds and forms of precipitation that occur are dependent on conditions in the atmosphere.
- The form condensing precipitation takes as it falls to earth depends on the temperature profile from the cloud to the ground.

Objective

After watching this segment and completing appropriate follow-up activities, the student should be able to

- describe the various types of precipitation and the conditions under which they form.

Learning Activities

Introduce students to the following terms: rain, snow, sleet, freezing rain, hail. Review these terms: condensation, precipitation.

If hail occurs in your area, collect the balls in plastic bags and store them in your freezer for students to cut and study when they are studying precipitation.

Media Resources

FILM LOOPS

INVESTIGATIONS IN SCIENCE: METEOROLOGY SERIES. 5 color film loops. Bailey-Film Associates.

STUDY PRINTS

WEATHER. 12 9" x 15" color prints. Hubbard Scientific Co.

TRANSPARENCIES

METEOROLOGY SET. 27 transparencies.
Ward's Natural Science Establishment, Inc.

Teacher References

Couchman, J. Kenneth, et al. 1972. *Snow and Ice: Examining Your Environment Series.* Minneapolis, MN: Winston Press.

LeChapelle, Edward R. 1960. *Field Guide to Snow Crystals.* Seattle: Univ. of Washington, Press.

National Weather Service. 1971. *Precipitation Probability Forecasts.* Washington, DC: U. S. Government Printing Office. (pamphlet)

9-3

Snow

Segment Synopsis

Snow is very special to most people. Some love it. Some hate it. But few students have experienced snow as it occurs in high mountain country. This five minute talk on Mount Mitchell in the heart of the Appalachian Blue Ridge mixes facts about snow with the special mood that only snow can create.

Concepts

- Snow is one type of precipitation.
- Snow plays an important role in the ecologic balances of mountain regions.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- interpret some of the "special" moods and ecstatic feelings snow can evoke
- explain several ways in which snow affects the mountain environment.

Learning Activities

Have students describe snow in their own way using stories, poems, prints, etc.

Have students collect and preserve snowflakes for study.

Teacher References

Bentley, W. A., and Humphreys, W. J. 1964. *Snow Crystals.* New York: Dover Publications, Inc.

Couchman, J. Kenneth, et al. 1972. *Snow and Ice: Examining Your Environment Series.* Minneapolis, MN: Winston Press.

Hodge, William T. 1973. *Climatic Data Report Southeastern Snow Storm, February 8-11, 1973.* NOAA Technical Memorandum EDS NCE-2. Asheville, NC: National Climatic Center.

LaChapelle, Edward R. 1969. *Field Guide to Snow Crystals.* Seattle: Univ. of Washington Press.

National Weather Service. 1975. *Winter Storms.* Washington, DC: U. S. Government Printing Office. (pamphlet)

Schaefer, Vincent J. 1964. Preparation of permanent replicas of snow, frost, and ice. *Weatherwise* 17(6): 3-11.

Schreiner, William, and Kelling, Norma J. 1972. How to catch a snowflake. *Science and Children* Dec: 24.

Szafarowicz, Joseph T. 1972. Making enlargments of snowflake patterns. *Science and Children* Dec: 25.

10

Cyclonic Storms

Cyclonic Storms

Program Overview

A knowledge of cyclonic storm formation and life cycle is basic to understanding how the atmosphere functions and how its behavior is forecast. This one segment program uses a television program rehearsal as the format in which the behavior of cyclonic storms is discussed and illustrated.

Textbook References

- A SEARCH FOR UNDERSTANDING
    - Ch. 15-4: Air Masses and Thunderstorms, pp. 493-499
- MODERN EARTH SCIENCE
    - Ch. 22: Weather, pp. 457-478
- PATTERNS IN OUR ENVIRONMENT
    - Ch. 7-1: Heavy and Light Air, pp. 174-176
    - Ch. 7-5: Reading Cloud Patterns, pp. 187-188
- THE WORLD WE LIVE IN
    - Ch. 38: Air Masses and Fronts, pp. 569-580
    - Ch. 39: Storms and Weather Forecasts, pp. 581-602
- EARTH SCIENCE: A LABORATORY APPROACH
    - Ch. 9-10: The Contact Region Between Two Air Masses, pp. 209-211
- EARTH SCIENCES: IIS
    - No references
- FOCUS ON EARTH SCIENCE
    - Ch. 10-3: Weather, pp. 188-193
- HOLT: EARTH SCIENCE
    - Ch. 10: Weather, pp. 276-312
- INVESTIGATING THE EARTH
    - Ch. 7: Wind, Weather, and Climate, pp. 141-166
- OUR ENVIRONMENT IN SPACE
    - Ch. 14: Energy Releases in the Atmosphere, pp. 238-297
- PATHWAYS IN SCIENCE
    - Unit V: Predicting the Coming Weather, pp. 245-288

Student Readings

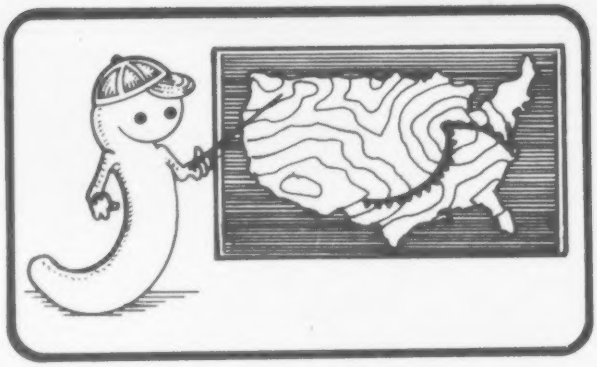
Holford, Ingrid. *Interpreting the Weather. A Practical Guide for Householders, Gardners, Motorists, and Sportsmen.* North Pomfret, VT: David and Charles, Inc., 1973.

Ludlam, F. H., and R. S. Scorer. *Cloud Study: A Pictorial Guide.* Bracknell, Berks, England: Royal Meteorological Society, n. d.

Scorer, Richard, and Harry Wexler. *Cloud Studies in Color.* New York: Pergamon Press, 1968.

Tufty, Barbara. *1001 Questions Answered About Storms and Other Natural Air Disasters.* New York: Dodd, Mead and Co., 1970.

10-1



Cyclonic Storms

Segment Synopsis

What begins as trouble during a TV program rehearsal turns into a teaching session when the floor manager, played by Shae Merritt, wants to know more about an impending cyclonic storm. The program begins by describing the life cycle of a hypothetical, classic cyclone that forms over New Mexico and travels to New England. It explains the types of fronts encountered and the weather associated with each. It shows that winds blow in different directions depending on the pressure system: counterclockwise about a low pressure system and clockwise about a high pressure system. Then a real storm that crossed the U. S. in May of 1971 is followed from its formation to its occlusion six days later. Students have an opportunity to observe the difference between theoretical and actual storms including the smaller but violent effects of thunderstorms and tornadoes formed within the larger storm system.

Concepts

- When two dissimilar air masses meet, interaction along the interface may result in the formation of a storm system.
- Storm systems tend to have life cycles that allow description, classification, and prediction.
- The type of clouds and forms of precipitation that occur are dependent on conditions in the atmosphere.
- Stratoform clouds, producing steady precipitation, result from the gradual lifting of air masses.
- Cumuloform clouds, producing showery precipitation, result from small scale convection.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain how air masses form, move, and interact to produce fronts
- describe the various types of clouds and the conditions under which they form
- describe the sequence of events in an ordinary cyclonic storm
- describe warm, cold, stationary, and occluded fronts in terms of behavior and characteristics.

Learning Activities

Review the following major ideas with students: air masses, cold front, warm front, occluded front, cloud types related to fronts, wind belts.

Have students prepare displays showing the stages of a cyclonic storm.

Have students plot cyclonic storm stages and positions from back issues of NOAA newspaper weather maps. Students may wish to "predict" the storm's location and verify it on the following day. Note: Because atmospheric conditions vary, you should not expect any storm to follow the "classic" pattern.

Media Resources

FILMS

AIR MASSES AND FRONTS--THE COLD FRONT. 16mm. 9 min. sd. color. U. S. Air Force, 1962.

AIR MASSES AND FRONTS--FRONTS AND THE SURFACE WEATHER MAP. 16mm. 10 min. sd. color. U. S. Air Force, 1962.

AIR MASSES AND FRONTS--THE OCCLUDED FRONT. 16mm. 9 min. sd. color. U. S. Air Force, 1962.

AIR MASSES AND FRONTS--THE WARM FRONT. 16mm. 11 min. sd. color. U. S. Air Force, 1962.

SLIDES

WHAT ON EARTH? SLIDE SET M/10.

TRANSPARENCIES

CLOUD TYPES. 1 color transparency. Hammond, Inc.

CLOUD TYPES. 2 color transparencies. Hubbard Scientific Co.

FRONTAL MOVEMENT. 1 color transparency. Hubbard Scientific Co.

METEOROLOGY SET. 27 transparencies. Ward's Natural Science Establishment, Inc.

WARM AND COLD FRONTS. 1 color transparency. Hubbard Scientific Co.

Teacher References

Geer, Ira W. 1975. *Weather Study--A Guide for Conducting a School Weather Study Utilizing Televised Weather Maps*. Brockport, NY: National School Weather Project, State University of New York.

National Weather Service. *Daily Weather Maps*. Weekly Series. Washington, DC: U. S. Government Printing Office. (by subscription)

11

The Nature of Violent Storms

Thunderstorms
Tornadoes
Hurricanes

Program Overview

Three types of violent storms affect our lives. Each of the three program segments is devoted to one of these severe local storms. The first segment chronicles the life cycle of a typical thunderstorm and illustrates the development of hail and lightning. The second segment looks at man's scant knowledge about the small but violent storm, the tornado and the final segment follows Hurricane Donna's 1960 path of destruction up the Atlantic Coast.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 15-4: Air Masses and Thunderstorms, pp. 493-499
  - Ch. 15-6: Hurricanes and Tornadoes, pp. 507-513
- MODERN EARTH SCIENCE
  - Ch. 22: Weather, pp. 457-478
- PATTERNS IN OUR ENVIRONMENT
  - No references
- THE WORLD WE LIVE IN
  - Ch. 39: Storms and Weather Forecasts, pp. 581-602
- EARTH SCIENCE: A LABORATORY APPROACH
  - No references
- EARTH SCIENCE: IIS
  - No references
- FOCUS ON EARTH SCIENCE
  - Ch. 10-3: Weather, pp. 188-193
  - Ch. 10-4: Clouds, pp. 194-195
- HOLT: EARTH SCIENCE
  - Ch. 10: Weather, pp. 276-312
- INVESTIGATING THE EARTH
  - Ch. 7: Wind, Weather, and Climate, pp. 141-166
- OUR ENVIRONMENT IN SPACE
  - Ch. 14: Energy Releases in the Atmosphere, pp. 238-298
- PATHWAYS IN SCIENCE
  - V Ch. 5: The Freaks of Weather, pp. 271-277

Student Readings

Battan, Louis J. *The Nature of Violent Storms.* Garden City, NY: Doubleday and Co., Inc., 1961.

__________. *The Thunderstorm.* New York: New American Library, 1964.

Bell, Thelma H. *Thunderstorms.* New York: Viking Press, Inc., 1960.

Bendick, Jeanne. *Lightning.* Chicago: Rand McNally and Co., 1961.

Branley, Franklyn M., and Leonard Kessler. *Owlie Skywarn: Tornado Warning.* Washington, DC: U. S. Government Printing Office, n. d.

__________. *Owlie Skywarn: Hurricane Warning.* Washington, DC: U. S. Government Printing Office, n. d.

Brindze, Ruth. *Hurricanes: Monster Storms From the Sea.* New York: Atheneum, 1973.

Brown, Billye, and Walter R. Brown. *Historical Catastrophies: Hurricanes and Tornados.* New York: Addison-Wesley Publishing Co., Inc., 1972.

Irving, Robert. *Hurricanes and Twisters.* New York: Alfred A. Knopf, Inc., 1957.

Keine, Martin L. *Lightning and Thunder.* New York: Julian Messner, Inc., 1969.

Schonland, Basil. *The Flight of the Thunderbolt.* Oxford: Clarendon Press, 1964.

Sloane, Eric. *Book of Storms.* New York: Duell, Sloan and Pearce, Inc., 1966.

Stewart, G. R., *Storm.* New York: Modern Library, Inc., 1947.

Viemeister, Peter E., *The Lightning Book.* Cambridge, MA: M.I.T. Press, 1972.

Weiss, Malcolm E. *Storms: From the Inside Out.* New York: Julian Messner, Inc., 1973.

Wrems, John E. *The Tornado.* Garden City, NY: Doubleday and Co., Inc., 1977.

Thunderstorms

Segment Synopsis

Thunderstorms are perhaps the most common and thus best known of the short-lived violent storms. Yet very few people understand how they develop or how they behave. This segment illustrates the development and life cycle of the thunderstorm. It describes the stages of the storm and characteristic features of each. Special attention is paid to the phenomena of hail and lightning. Students are shown how lightning develops and how to protect themselves if they are caught in the open during a thunderstorm.

Concept

- Storm systems have life cycles that allow description, classification, and prediction.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- describe the sequence of events in an ordinary thunderstorm
- list and explain several safety precautions that may be taken to avoid being struck by lightning
- explain the difference between a severe thunderstorm watch and a thunderstorm warning.

Learning Activities

Review the following ideas: convection, precipitation, hail formation

Have students write descriptions of their own personal impressions of a thunderstorm and/or lightning.

Have students observe a thunderstorm from a safe place. They might also want to take pictures to record what happens during the storm and then later use the pictures to illustrate a class report.

Have students research and report on local deaths and injuries due to lightning.

Have student photographers try to photograph lightning from a safe place.

Media Resources

FILM

STORMS: THE RESTLESS ATMOSPHERE. 16mm. 22 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

STUDY PRINTS

WEATHER. 12 9" x 15" color prints. Hubbard Scientific Co.

POSTER

PORTRAIT OF THE THUNDERSTORMS. Winkle Inc., 1977.

Teacher References

Atlas, David, ed. 1963. *Severe Local Storms.* Meteorological Monographs Vol. 5, No. 27. Boston: American Meteorological Society.

Bell, Thelma A. 1960. *Thunderstorm.* New York: Viking Press, Inc.

Byers, Horace R., and Braham, R. R., Jr., 1949. *The Thunderstorm.* Washington, DC: U. S. Government Printing Office.

Chalmers, J. A. 1967. *Atmospheric Electricity.* 2nd ed. New York: Pergamon Press.

Flora, Snowden D. 1956. *Hailstorms of the United States.* Norman: OK: Univ. of Oklahoma Press.

Marshall, J. Lawrence. 1973. *Lightning Protection.* New York: John Wiley and Sons, Inc.

National Weather Service. 1973. *Lightning.* Washington, DC: U. S. Government Printing Office. (pamphlet)

________. 1973. *Lightning Safety.* Washington, DC: U. S. Government Printing Office. (pamphlet)

Uman, Martin H. 1969. *Lightning.* New York: McGraw-Hill Book Co.

Viemeister, Peter E. 1972. *The Lightning Book.* Cambridge, MA: M. I. T. Press.

11-2

Tornadoes

Segment Synopsis

Though tornadoes are small in size, they are incredibly destructive. Tornadoes destroy millions of dollars of property and kill several hundred people every year. This segment explores what is known and not known about tornadoes and why these storms are so hard to study. Rare aerial film footage illustrates water spouts and tornado tracks. The segment presents several possible safety measures which students can take to protect themselves if they are caught in the path of a tornado.

Concept

- Storm systems have life cycles that allow description, classification, and prediction.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- describe the life cycle of a tornado
- list and explain several safety precautions which should be taken in the event of a tornado
- explain the difference between a tornado watch and a tornado warning.

Learning Activity

Have students research and report on tornadoes that have occurred in their area of the state.

Media Resources

FILMS

NEOSHO, APRIL 24. 16mm. 14 min. sd. color. National Oceanic and Atmospheric Administration.

STORMS: THE RESTLESS ATMOSPHERE. 16mm. 22 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

TORNADO. 16mm. 15 min. sd. color. National Oceanic and Atmospheric Administration.

TORNADO: 4:40 P.M., XENIA, OHIO. 16mm. 55 min. sd. color. NBC-TV Films, Inc. (Peabody award winner)

STUDY PRINTS

WEATHER. 12 9" x 15" color prints. Hubbard Scientific Co.

POSTERS

Fujita, T. T. 1974. TORNADO MAP U. S. TORNADOES 1930-74. Univ. of Chicago.

OWLIE SKYWARN ON FLASH FLOODS. National Oceanic and Atmospheric Administration.

OWLIE'S TIPS ON LIGHTNING SAFETY. National Oceanic and Atmospheric Administration.

SIMULATION GAME

SAFE-CHECK BOARD GAME. Local/State Civil Preparedness Agency.

Teacher References

Flora, Snowden D. 1973. *Tornadoes of the United States.* Norman, OK: Univ. of Oklahoma Press.

National Weather Service. 1970. *Spotters Guide for Identifying and Reporting Severe Local Storms.* Washington, DC: U. S. Government Printing Office. (pamphlet)

__________. 1971. *Tornado Safety Rules.* Washington, DC: U. S. Government Printing Office. (poster)

__________. *Tornado Preparedness Planning.* Washington, DC: U. S. Government Printing Office.

__________. 1976. *Severe Local Storm Warning Service and Tornado Statistics, 1953-1976.* Washington, DC: U. S. Government Printing Office. (pamphlet)

__________. 1976. *Tornado.* Washington, DC: U. S. Government Printing Office. (pamphlet)

Stong, C. L. 1971. The amateur scientist--experiments with winds: A pendulum anemometer and miniature tornado. *Scientific American* 225(Oct.): 108-112.

Tepper, Morris. 1958. Tornadoes. *Scientific American* 198(May): 31-37.

Weigel, Edwin P. 1975. In a life-and-death arena, some new ideas about tornadoes. *NOAA Journal* 5(3): 1-10.

11-3

Hurricanes

Segment Synopsis

Hurricanes are infrequent but regular visitors to the Atlantic Coast. When they come, they bring widespread death and destruction through their high winds and torrential rains. This segment documents the history of Hurricane Donna which swept up the Atlantic Coast in September 1960. Although there is no such thing as a typical hurricane, Donna demonstrates many of the features which make the hurricane the most feared of all violent storms.

Concept

- Storm systems have life cycles that allow description, classification, and prediction.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- describe the life cycle of a typical hurricane
- list and explain several safety precautions which should be taken in the event of a hurricane
- explain the difference between a hurricane watch and a hurricane warning.

Learning Activities

Have students prepare a list of major hurricanes that have occurred over the last thirty years and map their routes of travel.

Have members of the class keep a hurricane tracking chart at the beginning of the school year. Now, while the class is studying storms, have the students report on their findings.

Have students research and report to the class about historically important hurricanes.

Media Resources

FILMS

FLOOD. 16mm. 15 min. sd. color. National Oceanic and Atmospheric Administration.

HURRICANE. 16mm. 27 min. sd. color. Aetna Life and Casualty, 1969.

HURRICANE DECISION. 16mm. 14 min. sd. color. National Oceanic and Atmospheric Administration, 1976.

HURRICANE HUNTERS. 16mm. 28 1/2 min. sd. color. Dept. of the Navy, 1970.

STORMS: THE RESTLESS ATMOSPHERE. 16mm. 22 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

STUDY PRINTS

WEATHER. 12 9" x 15" color prints. Hubbard Scientific Co.

TRANSPARENCIES

METEOROLOGY SET. 27 transparencies. Ward's Natural Science Establishment, Inc.

SIMULATION GAME

HURRICANE ZETA. Local/State Civil Preparedness Agency.

Teacher References

Douglas, Marjory S. 1976. *Hurricane.* rev. abr. ed. St. Simons Island, GA: Mockingbird Books.

Dunn, Gordon, and Banner, I. Miller, 1964. *Atlantic Hurricanes.* 2nd ed. Baton Rouge, LA: Lousiana State Univ. Press.

Malkus, Joanne Starr. 1957. The origin of hurricanes. *Scientific American* 197 (Aug.): 33-39.

National Weather Service. 1966. *Some Devastating North Atlantic Hurricanes of the 20th Century.* Washington, DC: U. S. Government Printing Office. (pamphlet)

________. 1971. *Hurricane Information and Atlantic Tracking Chart.* Washington, DC: U. S. Government Printing Office. (chart)

________. 1972. *Getting Through.* Silver Springs, MD: National Weather Service. (pamphlet)

________. 1972. *Flash Flood, Treacherous Torrent.* Washington, DC: U. S. Government Printing Office. (poster)

________. 1973. *Flash Floods.* Washington, DC: U. S. Government Printing Office. (pamphlet)

________. 1973. *Floods, Flash Floods, and Warnings.* Washington, DC: U. S. Government Printing Office.

________. 1975. *The Homeport Story.* Washington, DC: U. S. Government Printing Office.

________. 1976. *When a Hurricane Threatens.* Washington, DC: U. S. Government Printing Office. (pamphlet)

Roberts, Walter Orr. 1972. We're doing something about the weather. *National Geographic* 141(April): 518-555.

Tannehill, Ivan R. 1954. *Hurricanes: Their Nature and History.* Princeton, NJ: Princeton Univ. Press.

Weigel, Edwin. 1972. The flood that strikes in a flash. *NOAA Journal* 2 (July): 8-17.

12

Forecasting Tomorrrow's Weather

Assignment Weather

Suitland Forecasts Tomorrow's Weather

Program Overview

This program traces the process used by the National Weather Service to forecast the weather. In ASSIGNMENT WEATHER, two students take a tour of a regional forecast office to see how observations are made and forecasts issued. The second segment takes viewers behind the scenes of the National Forecast Center to see computers and meteorologists combine talents to forecast tomorrow's weather.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 15-7: The National Weather Service, pp. 513-517
- MODERN EARTH SCIENCE
  - Ch. 22: Weather, pp. 457-478
- PATTERNS IN OUR ENVIRONMENT
  - Ch. 4-17: Weather Maps, pp. 102-105
  - Ch. 4-18: Comparing Weather Maps and Satellite Weather Photos, p. 106
  - Ch. 7-2: Your Weather, pp. 177-183
- THE WORLD WE LIVE IN
  - Ch. 39: Storms and Weather Forecast, pp. 581-602
- EARTH SCIENCE: A LABORATORY APPROACH
  - No references
- EARTH SCIENCE: IIS
  - No references
- FOCUS ON EARTH SCIENCE
  - Ch. 10-3: Weather, pp. 188-193
- HOLT: EARTH SCIENCE
  - Ch. 10: Weather, pp. 276-312
- INVESTIGATING THE EARTH
  - Ch. 7: Wind, Weather, and Climate, pp. 141-166
- OUR ENVIRONMENT IN SPACE
  - Extending Unit 7: Weather Maps, pp. 322-323
  - Ch. 14: Energy Releases in the Atmosphere, pp. 283-297
- PATHWAYS IN SCIENCE
  - Unit 5: Predicting the Coming Weather, pp. 246-288

Student Readings

Atkinson, Bruce W. *The Weather Business: Observation, Analysis, Forecasting and Modification.* Garden City, NY: Doubleday and Co., Inc., 1969.

Battan, Louis J. *Radar Observes the Weather.* Garden City, NY: Doubleday and Co., Inc. 1962.

Fisher, R. M. *How About the Weather?* 2nd ed. New York: Harper and Row, 1958.

Harris, Miles F., and American Meteorological Society. *Opportunities in Meteorology.* rev. ed. Skokie, IL: Vocational Guidance, 1972.

Hubert, Lester F., and Paul E. Lehr. *Weather Satellites.* Waltham, MA: Blaisdell Publishing Co., 1967.

Laird, Charles, and Ruth Laird. *Weathercasting. A Handbook of Amateur Meteorology.* Englewood Cliffs, NJ: Prentice-Hall, Inc., 1955.

National Weather Service. *Precipitation Probability Forecasts.* Washington, DC: U. S. Government Printing Office, 1969. (pamphlet)

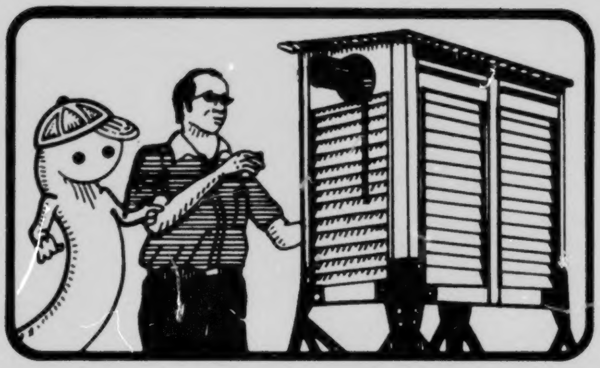
Sloane, Eric. *How You Can Forecast the Weather.* New York: Premier Press, 1962.

Spilhaus, A. F. *Weathercraft.* New York: Viking Press, Inc., 1951.

Wachter, Heinz. *Meteorology: Forecasting the Weather.* New York: Franklin Watts, Inc., 1973.

Wickham, P. G. *The Practice of Weather Forecasting.* London: Her Majesty's Stationery Office, 1970.

Yates, R. F. *Weather for a Hobby: A Guide to the Construction and Use of Weather Instruments for Amateurs.* rev. ed. New York: Dodd, Mead and Co., 1956.



Assignment Weather

Segment Synopsis

When Marylynn and Patrick were told to make a report on weather forecasting they didn't think it would lead to a tour of the Raleigh-Durham Forecast Office. Chief Meteorologist, Rue Rush shows Patrick and Marylynn how information is gathered, sent to other stations, and converted into local forecasts.

Concepts

- Storm systems have life cycles that allow description, classification, and prediction.
- Because the atmosphere follows the law of nature, its behavior can be predicted.
- Instruments are used to measure the properties of the atmosphere.
- Information derived from instruments is used to draw maps and formulate forecasts.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- list and explain the principles on which the more common meteorological instruments function
- explain and demonstrate how weather conditions are presented on a weather map
- construct a basic weather forecast.

Learning Activities

Have students prepare a list of things they think a meteorologist does and compare it to the activities they see in the film.

Have students collect and compare the information included in basic forecasts and extended outlooks.

Have students make their own weather measurements, convert them to station symbols, and post them, as the Weather Service does, on a continuing basis.

Media Resources

FILMS

RADAR EYES THE WEATHER, PART A - FUNDAMENTALS OF RADAR METEOROLOGY. 16mm. 25 min. sd. Dept. of the Air Force, 1961.

RADAR EYES THE WEATHER, PART B - ANALYSIS OF SEVERE WEATHER. 16mm. 21 min. sd. Dept. of the Air Force.

YOU AND THE WEATHER. 16mm. 25 min. sd. color. Texaco, Inc., 1956.

FILM LOOP

METEOROLOGY STATION. 1 color film loop. Ency. Britannica Ed. Corp. (produced by the National Film Board of Canada)

POSTER

EXPLANATION OF THE DAILY WEATHER MAP. U. S. Government Printing Office.

Teacher References

Earth Science Curriculum Project. 1968. *Weather Maps: How They Are Made and Used.* New York: Houghton Mifflin Co.

Haynes, Benarthur C. 1947. *Techniques of Observing the Weather.* New York: John Wiley and Sons, Inc.

Lester, Reginald M. 1955. *Observer's Book of Weather.* New York: Warne, Frederick, and Co., Inc.

Middleton, W.E.K., and Sphilhaus, Athelson F. 1953. *Meteorological Instruments.* 3rd rev. ed. Toronto: Univ. of Toronto Press.

National Oceanic and Atmospheric Administration. 1975. *Marine Weather Services.* Washington, DC: U. S. Government Printing Office. (pamphlet)

__________. 1977. *NOAA Weather Radio.* Silver Springs, MD: National Weather Service. (pamphlet)

Roberts, F. Charles. 1965. *Notes to Forecasters No. 1: On the Use of Probability Statements in Forecasts.* Technical Note 8-FCST-1. Washington, DC: National Oceanic and Atmospheric Administration. (pamphlet)

Sphilhaus, Athelson. 1951. *Weathercraft.* New York: Viking Press, Inc.

Witt, James F. 1976. Meteorology--base for a successful activity program. *The Science Teacher* Nov.: 42-44.

12-2

Suitland Forecasts Tomorrow's Weather

Segment Synopsis

This segment takes students on a tour of the National Weather Service in Suitland, Maryland. Here forecasts are made for the coming 12, 24, and 48 hours; long-range outlooks are also developed. Meteorologists are seen gathering data from around the world, studying and discussing the possibilities, making their forecasts, and then distributing information to the rest of the country.

Concepts

- Because the atmosphere follows the laws of nature, its behavior can be predicted.
- Information derived from instruments is used to draw maps and make forecasts.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- construct a basic weather forecast
- explain and demonstrate how weather conditions are presented on a weather map.

Learning Activity

Have students construct their own forecasts based on weather maps and local instrument data. Such forecasts might be included in daily school announcements.

Media Resources

FILMS

AIR WEATHER SERVICE OF THE USAF. 16mm. 14 min. sd. color. Dept. of the Air Force, 1966.

BOMEX. 16mm. 15 min. sd. color. National Oceanic and Atmospheric Administration.

GATE: THE ATLANTIC TROPICAL EXPERIMENT. 16mm. 28 min. sd. color. National Oceanic and Atmospheric Administration.

GATE TO WORLD WEATHER. 16mm. 28 min. sd. color. National Oceanic and Atmospheric Administration.

THE INCONSTANT AIR. 16mm. 27 min. sd. color. McGraw-Hill Book Co.

WEATHER BY THE NUMBERS. 16mm. 30 min. sd. color. Indiana Univ., 1966

WEATHER FORECASTING. 16mm. 22 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

WEATHER SATELLITES. 16mm. 15 min. sd. color. Ency. Britannica Ed. Corp.

FILMSTRIPS

CLOUDS AND RAIN AND THINGS PARTS I AND II. 2 color filmstrips, 2 cassette tapes. Guidance Associates, 1972. (a title in The Wonder Series)

Teacher References

Dennett, Joann Temple. 1972. Super model. *NOAA Journal* Jan: 32-34.

Haltiner, George J. 1971. *Numerical Weather Prediction.* New York: John Wiley and Sons, Inc.

Mizrahi, Abe, and Sullivan, Michael. 1973. Mathematical models and applications: suggestions for the high school classroom. *The Mathematics Teacher* 66(May): 394-402.

Monin, A. S. 1972. *Weather Forecasting as a Problem in Physics.* Cambridge, MA: M.I.T. Press.

National Oceanic and Atmospheric Administration. 1952. *Weather Forecasting,* Washington, DC: U. S. Government Printing Office.

National Weather Service. *Daily Weather Maps.* Weekly Series. Washington, DC: U. S. Government Printing Office. (by subscription)

NSTA Staff. 1971. Weather stations--their programs and management. *The Science Teacher* Dec: 25-27

U. S. Navy 1955. *Practical Methods of Weather Analysis and Prognoses.* Washington, DC: U. S. Government Printing Office.

13

Climate and Our Living World

Climate and Our Living World

Program Overview

Program 13 examines the way in which climate affects man. Utilizing student's prior experience with the life sciences, Dr. Hollis Rogers explains how climate helps determine the make-up of the plant community of North Carolina, from the subtropical coast to the Canadian mountain climates.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 16-1: The Study of Climates, pp. 520-523
  - Ch. 16-4: Temperature and Moisture Patterns, pp. 534-538
  - Ch. 16-5: The Patterns are Changed, pp. 538-543
- MODERN EARTH SCIENCE
  - Ch. 23: Elements of Climate, pp. 479-499
- PATTERNS IN OUR ENVIRONMENT
  - Ch. 7-13: Mountains, Hills and Bodies of Water Modify the Worldwide Patterns of Climate, pp. 207-208
- THE WORLD WE LIVE IN
  - Ch. 41: Factors that Control Climate, pp. 610-617
- EARTH SCIENCE: A LABORATORY APPROACH
  - Ch. 9-13: Patterns of Change in Weather, pp. 216-217
  - Ch. 4: A Microatmosphere at the Surface of the Earth, pp. 57-73
- EARTH SCIENCE: IIS
  - No references
- FOCUS ON EARTH SCIENCE
  - Ch. 10-5: Local Climates, pp. 196-203
- HOLT: EARTH SCIENCE
  - No references
- INVESTIGATING THE EARTH
  - Ch. 7: Wind, Weather, and Climate, pp. 141-166
- OUR ENVIRONMENT IN SPACE
  - Extending Unit 3: Man and City Climate, pp. 324-325
- PATHWAYS IN SCIENCE
  - No references

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Student Readings

Bova, Ben. *The Weather Changes Man.* New York: Addison-Wesley Publishing Co., Inc., 1974.

Flohn, Hermann. *Climate and Weather.* New York: McGraw-Hill Book Co., 1968.

May, Julian. *Climate.* Chicago: Follett Publishing Co., 1969.

Prince, J. H. *Weather and the Animal World.* New York: Thomas Nelson, Inc., 1975.

Rosenburg, Norman J. *Microclimate: The Biological Environment.* New York: John Wiley and Sons, Inc., 1974.

Climate and Our Living World

Segment Synopsis

This program portrays climate as an active force which shapes the environment. To show its effect, North Carolina is crossed from the coast to the mountains by professor Dr. Hollis Rogers, who knows the state, its plants and its climate thoroughly. He shows plants in each climatic region of the state and relates them to topography and the yearly weather cycle. The program highlights Hammocks Beach State Park, Merchant's Mill Pond in Gates County, Hanging Rock State Park, Blue Ridge Parkway, and Mt. Mitchell. At intermediate stops, changes in altitude and topography are noted and the water supply, ground cover, and yearly average weather cycles are discussed. The program introduces the concept of microclimates. No effort is made to present the statistical aspects of climate.

Concepts

- Energy and moisture are the principle elements of climate.
- The pattern of energy distribution is basically latitudinal.
- The pattern of energy distribution may be altered by landforms.
- The parts of the hydrologic cycle that involve air motion occurring in an orderly spatial arrangement over a period of years are called climates.

Objectives

After watching this program and completing appropriate follow-up activities, the student should be able to

- explain how atmospheric circulation creates climate
- explain how continental landmasses and landforms modify circulation and create climate
- give examples of various climates and show particularly how North Carolina climates relate to the world picture
- explain what a microclimate is, describe how it functions, and give examples.

Learning Activities

Ask students to create their own definition of climate and suggest ways that climate affects their lives.

Have students give reports on typical climates in various locations around the world and then use a world map to relate them to the general causes of climate.

Have students review the relation of insolation curves to climate.

Have students produce displays which relate wind patterns and seasonal shifts to a region's climate. You may wish to include the Southeast as a region and study the summer "Bermuda High."

Have students research and report on how man's activities have altered macro or microclimates and then draw conclusions about the future.

Media Resources

TRANSPARENCY

CLIMATE. 1 color transparency. Hubbard Scientific Co.

STUDY PRINT

WEATHER. 12 9" x 15" color prints. Hubbard Scientific Co.

Teacher References

Bureau of Outdoor Recreation. 1974. *Miniature Environments: An Environmental Education Handbook*. rev. ed. Washington, DC: U. S. Government Printing Office. (pamphlet)

Byrson, R. A., and Hare, F. K. 1973. *Climates of North America*. New York: Elsevier-North Holland Pub. Co.

Couchman, J. Kenneth, et al. 1972. *Mini-Climates: Examining Your Environment Series*. Minneapolis, MN: Winston Press.

Franklin, Thomas B. 1972. *Climates in Miniature*. Westport, CT: Greenwood Press, Inc.

Lowry, William P. 1969. *Weather and Life: An Introduction to Biometeorology*. New York: Academic Press.

National Oceanic and Atmospheric Administration. 1976. Climate and health. *NOAA Journal* 6(4): 51.

Neuberger, H., and Cahir, J. 1969. *Principles of Climatology: A Manual in Earth Science*. New York: Holt, Rinehart and Winston.

Opik, Ernest H. 1958. Climate and the changing sun. *Scientific American* 198(June): 85-90.

Plass, Gilbert N. 1959. Carbon dioxide and climate. *Scientific American* 201(July): 41-47.

14

The Atmosphere: Yesterday and Today

Recording Yesterday's Weather
Want to Buy a Bottle?
The Air We Breathe

Program Overview

This program considers the atmosphere as a whole. RECORDING YESTERDAY'S WEATHER looks at the atmosphere of the past through a visit to the National Climatic Center to learn how long term weather records are handled. Segment Two, WANT TO BUY A BOTTLE?, examines today's atmosphere in an ad for clean air. THE AIR WE BREATHE looks at the causes, effects, and possible cures of air pollution.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 14-1: The Nature of the Atmosphere, pp. 454-462
  - Ch. 16-1: The Study of Climates, pp. 520-523
- MODERN EARTH SCIENCE
  - Ch. 23: Elements of Climate, pp. 479-499
  - Ch. 24: Upsetting Nature's Balance, pp. 504-521
- PATTERNS IN OUR ENVIRONMENT
  - Ch. 7-6: A Temperature Inversion, pp. 189-190
  - Ch. 7-7: The Effect People Have on the Weather, pp. 191-192
  - Ch. 7-8: Climate Around the World, pp. 193-199
  - Ch. 7-9: Temperature Patterns, pp. 200-202
  - Ch. 7-12: World Rainfall Patterns, pp. 206-207
  - Ch. 7-14: Climates Around the World, pp. 208-212
- THE WORLD WE LIVE IN
  - Ch. 42: Climates of the World, pp. 618-636
  - Ch. 43: The Earth in Balance, pp. 637-646
- EARTH SCIENCE: A LABORATORY APPROACH
  - Ch. 9-12: Weather Systems of the World, pp. 213-216
  - Ch. 9-13: Patterns of Change in Weather, pp. 216-217
- EARTH SCIENCE: IIS
  - Idea 5-8: This is No Choking Matter, pp. 195-200
- FOCUS ON EARTH SCIENCE
  - Ch. 10-5: Local Climates, pp. 196-203
- HOLT: EARTH SCIENCE
  - No references
- OUR ENVIRONMENT IN SPACE
  - Extending Unit 3: Man and City Climate, pp. 324-325
- INVESTIGATING THE EARTH
  - Ch. 7: Wind, Weather, and Climate, pp. 141-166
- PATHWAYS IN SCIENCE
  - IV Ch. 9: Our Foul Air, pp. 234-239

Student Readings

Battan, Louis J. *The Unclean Sky--A Meteorologist Looks at Air Pollution.* Garden City, NY: Doubleday and Co., Inc., 1966.

Flohn, Hermann. *Climate and Weather.* New York: McGraw-Hill Book Co., 1968.

Hare, F. K. *The Restless Atmosphere.* New York: Harper and Row, 1963.

Landsberg, Helmut E. *Weather and Health--An Introduction to Biometeorology.* Garden City, NY: Doubleday and Co., Inc., 1969.

Lewis, Howard B. *With Every Breath You Take.* New York: Crown Publishers, Inc., 1965.

Sears, Roger, ed. *The World's Weather and Climate.* New York: Crown Publishers, Inc., 1974.

Recording Yesterday's Weather

Segment Synopsis

The recording and keeping of weather records is a little known but vital function of the National Weather Service. This segment takes students on a brief tour of the National Climatic Center in Asheville, N. C. to see how the Center collects, processes, stores, and uses world wide weather observations.

Concept

- Man's mind is his most important tool for interpreting natural events.

Objective

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain how climatic data is collected, stored, and used for long-term weather research.

Learning Activities

Ask students to suggest some kinds of data that might be kept at the National Climatic Center and ways that they might be used.

Have students use data summaries from the National Climatic Center to prepare profiles of the climate in their town, state, or region.

Media Resource

FILM

SCIENCE-NEW FRONTIERS: IS THE WEATHER CHANGING? 16mm. 16 1/4 min. sd. color. BFA Educational Media.

Teacher References

Canby, Thomas Y. 1977. The year the weather went wild. *National Geographic* 152 (6): 799-829.

Egan, Patrick J. 1977. Paleo-climatology: Diving the future from the past. *The Science Teacher* 44(9): 16-17.

Environmental Data Services. 1970. *Climates of the States: Climate of North Carolina*. Washington, DC: U. S. Government Printing Office.

________. 1972. *Climates of the World*. Washington, DC: U. S. Government Printing Office.

Ludlum, D. M. 1971. *Weather Record Book*. Princeton: Weatherwise, Inc.

National Oceanic and Atmospheric Administration. *Environmental Information Summaries*. Asheville, NC: National Climatic Center.

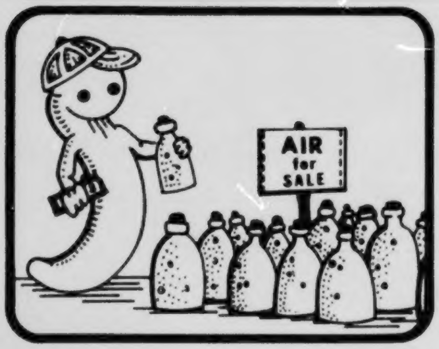
C-1	*Weather Records in Private Litigation*
C-2	*Local Climatological Data*
C-3	*Wind Chill*
C-4	*A Change of Climate*
C-5	*Temperature Extremes in the United States*
C-6	*Hourly Observations and Summary of Day Data*
C-7	*Weather Observations from Ocean Weather Stations*
C-8	*Winds Aloft Computation Sheet*
C-9	*Upper Air Observation*
C-10	*Radar Weather Observations*
C-11	*Cooperative Observers Climatological Observations*
C-12	*Wind Direction Versus Wind Speed Tabulations*
C-13	*Ceiling Visibility and Tabulations*
C-14	*Heating and Cooling Degree Day Data*
C-15	*Index of Hourly Synoptic and Autographic Original Records*
C-16	*Earth Resources Technology Satellite, ERTS/Landsat Data*

National Weather Records Center. 1969. *Key to Meteorological Records Documentation No. 4.11 Selective Guide to Climatic Data Sources*. Washington, DC: U. S. Government Printing Office.

Visher, S. S. 1966. *Climatic Atlas of the United States*. 2nd ed. Cambridge, MA: Harvard Univ. Press.

Wallis, Alva L., Jr., 1977. *Comparative Climatic Data Through 1976*. Asheville, NC: National Climatic Center.

Young, Gordon, 1970. Pollution, threat to man's only home. *National Geographic* 138(Dec.): 738-781.



Want to Buy a Bottle?

Segment Synopsis

This very short advertisement for clean air suggests that if man does not take steps to prevent air pollution, he may have to buy his clean air in bottles.

Concept

- The atmosphere is being contaminated with chemical agents and other foreign substances introduced by man.

Objective

After watching this segment and completing appropriate follow-up activities, the student should be able to

- identify his individual responsibility for correcting and preventing air pollution.

Learning Activity

This segment is designed to stimulate discussion. You may wish to have your class view it with little preparation and then initiate a follow-up discussion from which students can identify a personal responsibility for controlling and preventing air pollution.

14-3

The Air We Breathe

Segment Synopsis

In THE AIR WE BREATHE, air pollution is seen from a scientific point of view. Students observe some causes of the problem and the results of air pollution on plant and animal life and physical structures. Some possible solutions to the problem are given and the segment closes in an open-ended manner designed to stimulate discussion.

Concept

- The atmosphere is contaminated with chemical agents and other foreign substances introduced by man.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- give examples of the major sources of air pollution and describe some of the prevention efforts already under way
- identify his individual responsibility to correct and prevent air pollution.

Learning Activities

Have students write a description of the atmosphere and how it affects them. Then hand back the papers from Program 6 and have students compare them. Ask students what they think they have learned.

Build on the discussion from Segment 2. Instead of focusing on emotional issues, this time encourage students to explore the problems presented by air pollution in a rational scientific manner.

Have students measure local air pollution, compare the results to published data (if available) and then construct displays to inform other students about the quality of the air they breathe.

Invite a local air pollution control officer to speak to your classes.

Have students research and report on the success or failure of controlling air pollution in your area.

Media Resources

FILMS

AIR IS FOR BREATHING. 16mm. 29 min. sd. color. Shell Film Library, 1971.

AIR OF DISASTER. 16mm. 50 min. sd. color. National Medical Audiovisual Center.

AIR POLLUTION: TAKE A DEEP DEADLY BREATH. 16mm. 54 min. sd. color. National Medical Audiovisual Center.

BEWARE THE WIND. 16mm. 22 min. sd. color. National Medical Audiovisual Center.

THE POISONED AIR. 16mm. 50 min. sd. color. National Medical Audiovisual Center.

POLLUTION. 16mm. 3 min. sd. color. Astrafilms, Inc.

PROBLEMS OF CONSERVATION: AIR. 16mm. 15 min. sd. color. Ency. Britannica Ed. Corp.

FILMSTRIPS

POLLUTION. 6 color filmstrips. 2 cassette tapes. Holt, Reinhart and Winston.

Teacher References

Agricultural Research Search. 1972. *Testing for Air Pollution*. U. S. Dept. of Agriculture. Science Study Aid No. 5. Washington, DC: U. S. Government Printing Office. (pamphlet)

Cole, Henry S. 1973. Air pollution and weather: activities and demonstrations for science classes. *The Science Teacher* 40(Dec.): 38-44

Cox, David C. 1972. *How to...Investigate the Environment in the City: Air and Water*. Washington, DC: National Science Teachers Association. (pamphlet)

Couchman, J. Kenneth, et al. 1972. *Pollution: Examining Your Enviornment Series*. Minneapolis: MN: Winston Press.

Hindawi, Joseph I. 1970. *Air Pollution Injury to Vegetation*. National Air Pollution Central Administration, Pub. AP-71. Washington, DC: U. S. Government Printing Office.

Manufacturing Chemists Association. 1974. *Air Pollution Causes and Cures*. Washington, DC: Manufacturing Chemists Association.

Schultz, Robert F. 1973. *Environmental Experiments...From Edison*. Detroit: Thomas Alva Edison Foundation.

Scorer, R. S. 1968. *Air Pollution*. New York: Pergamon Press.

Stern, Arthur C., et al. 1973. *Fundamentals of Air Pollution*. New York: Academic Press.

Weaver, Elbert C. 1971. *Environmental Pollution Experiences/Experiments/Activities*. New York: Holt, Reinhart and Winston.

Unit 3

Oceanography

Oceanography and shore processes are combined in Programs 15 through 19 to introduce students to marine and near marine environments. The processes, occupations, and major concepts of oceanography are presented in Programs 15 and 16 as students take part in a 10 day cruise on Duke University's research vessel, EASTWARD. It is a realistic picture of life on board ship including the hard work, lack of comforts, successes, and failures that accompany any true effort in oceanographic research.

Programs 17, 18, and 19 explain the basic principles underlying physical and life processes near the sea. Students study waves, beach features, sand motion, windblown sand, and shorelines. They are guided across the ecosystems on a barrier island and begin to look at the problems created by man's activity along the coast.

Throughout the unit, there is a continuing effort to show the beauty, wilderness, and attraction of the sea that may explain the mysterious lure it exerts on nearly every individual.

References

BOOKS

Gross, Grant M. 1977. *Oceanography: A View of the Earth.* 2nd ed. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Holmes, Arthur. 1965. *Principles of Physical Geology.* 2nd ed. New York: Ronald Press Co.

Hunt, Charles B. 1974. *Natural Regions of the United States and Canada.* San Francisco: W. H. Freeman and Co.

Mauldin, L., and Frankenburg, D., eds. 1978. *North Carolina's Marine Education Manual.* Chapel Hill, NC: UNC Marine Science Programs.

Menard, H. W., ed. 1977. *Ocean Sciences.* Readings from *Scientific American.* San Francisco: W. H. Freeman and Co.

National Oceanic and Atmospheric Administration. *NOAA's Oceanography Packet.* Rockville, MD: Physical Sciences Service Branch, NOAA.

Shephard, Francis P., and Wanless, Harold R. 1971. *Our Changing Coastlines.* New York: McGraw-Hill Book Co.

Strahler, Arthur N. 1971. *The Earth Sciences.* 2nd ed. New York: Harper and Row.

Thornbury, William D. 1969. *Principles of Geomorphology.* 2nd ed. New York: John Wiley and Sons, Inc.

Weyl, Peter K. 1970. *Oceanography: An Introduction to the Marine Environment.* New York: John Wiley and Sons, Inc.

PERIODICALS

JOURNAL OF MARINE EDUCATION. quarterly.

NOAA JOURNAL. quarterly.

OCEANUS. Woods Hole Oceanographic Institution. quarterly.

SEA CHEST. Cape Hatteras School, Buxton N. C. quarterly.

SEA FRONTIERS. International Oceanographic Foundation. quarterly.

SEA WORLD. quarterly.

15

Science and the Sea: Part I

Science and the Sea: Part I

Program Overview

Programs 15 and 16 follow the research vessel, EASTWARD, through a normal cruise and provide students with an opportunity to watch and listen to physical oceanographers, marine biologists, and marine geologists at work. An attempt is made to give physical, biological and geological sciences equal emphasis in these two programs.

EASTWARD is funded by Duke University and the National Science Foundation and operates from the Duke University Marine Laboratory at Beaufort, North Carolina. The ship is a typical oceanographic research vessel designed to work in the Atlantic from Newfoundland to the Caribbean. She can support a scientific party of fifteen and an equal number of crewmen for twenty-one days at sea. She cruises up to five thousand miles at ten and one-half knots without refueling.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 10-1: Ocean Water, pp. 293-296
  - Ch. 10-8: The Wealth of the Ocean, pp. 331-336
- MODERN EARTH SCIENCE
  - Ch. 15: The Oceans, pp. 316-334
  - Ch. 16: Seawater, pp. 335-351
- PATTERNS IN OUR ENVIRONMENT
  - Ch. 6-3: Seawater, p. 152
- THE WORLD WE LIVE IN
  - Ch. 18: Exploration of the Sea, pp. 260-271
  - Ch. 19: The Composition and Temperature of Ocean Waters, pp. 272-281
- EARTH SCIENCE: A LABORATORY APPROACH
  - Ch. 10-1: The Oceans and the Seas, pp. 221-222
  - Ch. 10-2: Salinity and the Density of Seawater, pp. 222-224
  - Ch. 10-3: Temperature and the Density of Seawater, pp. 225-227
  - Ch. 10-4: Interactions Between the Atmosphere and the Oceans, pp. 228-230
- EARTH SCIENCE: IIS
  - Idea 6-3: Why is the Ocean Salty? pp. 211-216
  - Idea 6-7: There may be Something in It for You, pp. 231-236
- FOCUS ON EARTH SCIENCE
  - Ch. 11-1: The Hydrologic Cycle, pp. 204-205
  - Ch. 11-2: Composition of the Ocean, p. 206
  - Ch. 11-3: Life in the Ocean, pp. 207-209
  - Ch. 12-1: Major Circulation Patterns, pp. 223-224
  - Ch. 12-2: Local Currents, pp. 225-227

- HOLT: EARTH SCIENCE
  - Ch. 11: The Oceans, pp. 313-340
  - Ch. 12: Motions of the Sea, pp. 342-367
- INVESTIGATING THE EARTH
  - Ch. 4: Water in the Sea, pp. 77-100
- OUR ENVIRONMENT IN SPACE
  - Ch. 15: Energy Exchanges Within the Oceans, pp. 299-319
- PATHWAYS IN SCIENCE
  - VI Ch. 1: The Earth's Waters, pp. 292-298
  - VI Ch. 2: The Nature of Ocean Water, pp. 299-303
  - VI Ch. 5: The Citizens of the Ocean, pp. 316-322

Student Readings

Barnes, H. *Oceanography and Marine Biology: A Book of Techniques.* New York: Macmillan Publishing Co., Inc., 1959.

Bartlett, Jonathan, ed. *The Ocean Environment.* Bronx: H. W. Wilson, 1971.

Boyer, Robert. *The Story of Oceanography.* New York: Harvey House, Inc., 1975.

Carson, Rachel. *The Sea Around Us.* New York: Oxford Univ. Press, 1961.

Chapman, Charles F. *Piloting, Seamanship and Small Boat Handling.* New York: Motor Boating Inc., 1966.

Cousteau, Jacques-Yves. *The Under Sea Discoveries of Jacques-Yves Cousteau.* New York: Doubleday and Co., Inc., 1975. (a series of 20 titles about life and exploration under the sea).

Davis, Kenneth S., and Luna Leopold. *Water.* Morristown, NJ: Silver Burdett Co., 1966. (a title in the LIFE Science Library).

Engel, Leonard. *The Sea.* Morristown, NJ: Silver Burdett Co., 1969. (a title in the LIFE Nature Library Series)

Herring, Peter J., and Malcolm R. Clarke, ed. *Deep Oceans.* New York: Praeger Publishers, 1971.

National Oceanic and Atmospheric Administration. *Navigate Safely.* Washington, DC: U. S. Government Printing Office, 1973. (pamphlet)

U. S. Geological Survey. *Marine Geology: Research Beneath the Sea.* Washington, DC: U. S. Government Printing Office.

U. S. Geological Survey. *Why Is the Ocean Salty?* Washington, DC: U. S. Government Printing Office.

U. S. Government. *Questions and Answers About the Oceans.* Washington, DC: U. S. Government Printing Office, 1968.

Verduin, Jacob. *Field Guide to Lakes.* ESCP, Pamphlet Series No. 8. Boston: Houghton Mifflin Co., 1971. (pamphlet)

Voss, Gilbert L. *Oceanography: A Golden Guide.* New York: Western Publishing Co., Inc., 1972.

Science and the Sea: Part I

Segment Synopsis

Programs 15 and 16 follow the EASTWARD through a normal cruise. Program 15 begins as the ship returns to port from one geologic cruise and takes on a new scientific party. Students meet the scientists and for the next eleven days observe them as they go about their duties and conduct their investigations.

The area being studied by EASTWARD scientists is an embayment stretching from Charleston, South Carolina to Saint Augustine, Florida. The shoreline has a number of small coastal islands; the ocean bottom is flat, sloping gently to the east until it reaches the continental slope. This water mass is primarily confined between the coast and the Gulf Stream and is relatively unpolluted. Each study being carried out by the EASTWARD on this and other related cruises helps establish a baseline of information from which future changes can be evaluated.

In this program, the EASTWARD sails to a point off the coast at Charleston, South Carolina, at which point she begins tracing a series of six transects. Each transect is a line of stations beginning in shallow water and ending in water more than five hundred meters deep. At each station physical data are collected to study water masses and currents. The sum of the data collected at the transect stations is designed to yield a thorough coverage of the area being studied.

The program closes with an indication that the cruise will be continued in the following program.

Concepts

- Oceans are large bodies of water covering seventy percent of the earth's surface.
- The oceans of the world are the earth's most prominent geographic features.
- The major features of ocean circulation are determined by atmospheric circulation and by the action of gravity on seawater of varying density.

Objectives

After watching this program and completing appropriate follow-up activities, the student should be able to

- explain some of the methods used by modern oceanographers to research the sea
- explain what constitutes seawater.

- Seawater is a dilute solution.

- locate and name the major oceans of the water
- demonstrate and explain how wind drives currents
- demonstrate and explain how gravity acts on seawater of different densities to cause currents
- use models or charts to trace the routes of some of the major currents of the world and explain how they modify climate

Learning Activities

Have students conduct the following investigations from Miles F. Harris's, et al. Earth Science Curriculum Project textbook, INVESTIGATING THE EARTH (1973), published by the Houghton Mifflin Company, Boston, Massachusetts:

4-6	Investigating the Coriolis Effect
4-7	Investigating Currents
10-6	Investigating Turbidity Currents

Have students compare currents and point out probable courses if coriolis force did not affect the currents' paths.

Have students research and report on the various types of instruments used in oceanographic research. If a lake, pond or sound is nearby, have students construct simple instruments and gather data.

Set up a seeking session using globes and black outline maps. Have students locate and label major oceans (5 or 6 maximum).

Have students weigh salt and water to make 1 kilogram of seawater. Have students prepare a graphic model, such as a bar graph, showing the composition of seawater.

Media Resources

FILMS

- AIRBORNE OCEANOGRAPHY: OCEANOGRAPHER OF THE NAVY. 16mm. 23 min. sd. color. Dept. of the Navy.
- ASSAULT ON THE UNKNOWN: THE OCEANOGRAPHIC RESEARCH PLATFORM. 16mm. 28 1/2 min. sd. color. Dept. of the Navy.
- GULF STREAM. 16mm. 28 min. sd. color. Dept. of the Navy.

MILITARY OCEANOGRAPHY: BATHYTHERMOGRAPH OBSERVATIONS. 16mm. 16 min. sd. color. Dept. of the Navy.

MILITARY OCEANOGRAPHY: OCCUPYING AN OCEANOGRAPHIC STATION. 16mm. 29 min. sd. color. Dept. of the Navy.

THE NATURE OF SEAWATER. 16mm. 29 min. sd. color. Dept. of the Navy.

THE POISONED SEA. 16mm. 27 min. sd. color. Moonlight Productions.

THE RESTLESS SEA. 16mm. 53 min. sd. color. Bell Telephone Co.

THE UNDERSEA WORLD OF JACQUES COUSTEAU FILM SERIES. 16mm. sd. color. Doubleday Multimedia, 1970. (a series of films of varying length)

WATER MASSES OF THE OCEAN. 16mm. 45 min. sd. color. Dept. of the Navy.

FILM LOOPS

OCEANOGRAPHY. 6 color film loops. Hubbard Scientific Co.

FILMSTRIPS

CAUSE OF OCEAN CURRENTS. OCEAN CURRENTS OF THE WORLD. 2 color filmstrips. Stone Productions.

CHEMICAL OCEANOGRAPHY. 1 color filmstrip. disc recording. Ency. Britannica Ed. Corp.

AN INTRODUCTION TO OCEANOGRAPHY. 1 color filmstrip. disc recording Ency. Britannica Ed. Corp.

PHYSICAL OCEANOGRAPHY. 1 color filmstrip. disc recording. Ency. Britannica Ed. Corp.

THE OCEAN IS MANY THINGS. 6 color filmstrips. Churchill Films.

TRANSPARENCIES

OCEANOGRAPHY. 4 color transparencies. Hubbard Scientific Co.

OCEANOGRAPHY. 18 color transparencies. Hubbard Scientific Co.

SLIDES

WHAT ON EARTH? SLIDE SET 0/15-16.

CHART

MARINE WEATHER SERVICES CHART - CAPE HATTERAS, NORTH CAROLINA TO SAVANNAH, GA., 1973. Washington, DC: U. S. Government Printing Office.

Teacher References

Baird, Gerald. 1974. Oceanography in a swimming pool. *The Science Teacher* April: 7-9.

Barber, Richard T., and Newton, John G. 1974. 1973-74 *Progress Report, Duke University Cooperative Oceanography Program.* Beaufort, NC: Duke Univ. Marine Laboratory.

Emerson, Paul. 1970. Build your own portable water tester. *Popular Science* Sept.: 127-132.

Evans, Thomas P. 1971. The secchi disk: an instrument for measuring water transparency. *The Science Teacher* April: 57-58.

Gordon, Bernard L., ed. 1972. *Man and the Sea: Classic Accounts of Marine Explorations.* Garden City, NY: Doubleday Natural History Press.

Hon, Will. 1971. Row boat oceanography. *The Science Teacher* January: 27-30.

Kline, John L. 1972. Environmental science institute develops water sampler. *Journal of Geological Education* Sept.: 208-210.

Lind, Owen T. 1974. *Handbook of Common Methods in Limnology.* St. Louis: C. V. Mosby Co.

MacIntyre, Ferren. 1970. Why the sea is salt. *Scientific American* 223(5): 104-115.

Munk, Walter. 1955. The circulation of the oceans. *Scientific American* 193 (Sept.): 96-102.

National Oceanic and Atmospheric Administration. 1976. *National Ocean Survey Publications for Safe Navigation.* Washington, DC: U. S. Government Printing Office. (pamphlet)

Newton, J. G., Pilkey, O. H., and Blanton, J. O. 1971. *An Oceanographic Atlas of the Carolina Continental Margin.* Beaufort, NC: Duke Univ. Marine Laboratory.

Rakoff, Frank G. 1972. Automatic water sampler monitors pollution. *Popular Science* August: 112.

U. S. Government. 1975. *Tide and Current Glossary.* Washington, DC: U. S. Government Printing Office.

U. S. Naval Oceanographic Office. 1963. *Bathythermography Observations: Oceanographic Office Observers Manual.* 3rd ed. Pub. No. 606-c. Washington, DC. (pamphlet)

____________. 1967. *Science and the Sea.* Washington, DC: U. S. Government Printing Office. (pamphlet)

U. S. Naval Oceanographic Office, U. S. Coast and Geodetic Survey, and U. S. Lake Survey. 1963. *Nautical Chart Symbols and Abbreviations.* Chart No. 1. Washington, DC: U. S. Naval Oceanographic Office. (pamphlet)

U. S. Navy Hydrographic Office. 1950. *Sea and Swell Observations: Hydrographic Office Observers Manual.* H. O. Pub. No. 606-e. Washington, DC. (pamphlet)

____________. 1966. *Oceanography.* American Practical Navigator, Part 6. H. O. Pub. No. 9-Part 6. Washington, DC: U. S. Government Printing Office. (pamphlet)

Villers, Alan. 1971. Captain Cook: the man who mapped the Pacific. *National Geographic* 140(Sept.): 297-349.

16

Science and the Sea: Part II

Science and the Sea: Part II

Program Overview

Program 16 continues the oceanographic cruise begun in Program 15 on the Duke University research vessel EASTWARD. Since much of Program 15 was devoted to ship operations and physical oceanography, Program 16 concentrates on marine biology and marine geology.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 10-2: The Edges of the Oceans, pp. 297-302
  - Ch. 10-3: Exploring the Depths, pp. 303-310
  - Ch. 10-4: Features of the Ocean Depths, pp. 310-313
- MODERN EARTH SCIENCE
  - Ch. 15: The Oceans, pp. 316-334
  - Ch. 17: Motions of the Sea, pp. 352-374
- PATTERNS IN OUR ENVIRONMENT
  - Ch. 6-7: Planet Water, p. 155
  - Ch. 8-8: Cross Sections of Continents and Oceans, pp. 233-235
- THE WORLD WE LIVE IN
  - Ch. 20: The Sea Floor and Its Sediments, pp. 282-292
  - Ch. 21: Ocean Currents, pp. 292-302
- EARTH SCIENCE: A LABORATORY APPROACH
  - Ch. 10-7: The Deep Floor of the Ocean, p. 234
- EARTH SCIENCE: IIS
  - Idea 6-1: The Shape of Things to Come, pp. 201-206
  - Idea 6-4: Giant Rivers of the Oceans, pp. 217-220
  - Idea 6-8: The Treasure of Davy Jones, pp. 237-240
- FOCUS ON EARTH SCIENCE
  - Ch. 11-4: Topography of the Ocean Floor, pp. 210-215
  - Ch. 11-5: Deep-Sea Deposits, pp. 216-222
  - Ch. 11-3: Life in the Ocean, pp. 207-209
- HOLT: EARTH SCIENCE
  - Ch. 11: The Oceans, pp. 313-340
  - Ch. 12: Motions of the Sea, pp. 342-267
- INVESTIGATING THE EARTH
  - Ch. 10: Sediments in the Sea, pp. 211-232
- OUR ENVIRONMENT IN SPACE
  - Ch. 23: Rifting of Ocean Basins and Continents, pp. 491-499
- PATHWAYS IN SCIENCE
  - VI Ch. 3: The Topography of the Ocean Floor, pp. 304-309
  - VI Ch. 5: The Citizens of the Ocean, pp. 316-322
  - VI Ch. 6: Gifts from the Sea, pp. 323-330

Student Readings

Barnes, H. *Oceanography and Marine Biology: A Book of Techniques.* New York: Macmillan Publishing Co., Inc., 1959.

Borgese, Elizabeth M. *The Drama of the Oceans.* New York: Harry N. Abrams, Inc., 1975.

Carson, Rachel. *The Sea Around Us.* New York: Oxford Univ. Press, 1961.

Chapman, Charles F. *Piloting, Seamanship and Small Boat Handling.* New York: Motor Boating, Inc., 1966.

Davis, Kenneth S., and Luna Leopold. *Water.* Morristown, NJ: Silver Burdett Co., 1966. (title in the LIFE Science Library)

Gibbs, Tony. *Navigation: Finding Your Way on Sea and Land.* New York: Franklin Watts, Inc., 1975.

Hull, Seabrook E. W. *The Atom and the Ocean.* Washington, DC: U. S. Atomic Energy Commission, 1968.

Limburg, Peter R., and James B. Sweeney. *102 Questions and Answers About the Sea.* New York: Julian Messner, Inc., 1975.

Marx, Robert F. *The Underwater Dig: An Introduction to Marine Archeology.* New York: Henry Z. Walck, Inc., 1976.

National Oceanic and Atmospheric Administration. *Navigate Safely.* Washington, DC: U. S. Government Printing Office, 1973. (pamphlet)

Oxenhorn, Joseph M., and Burton I. Goldfield. *Oceanography and Our Future.* New York: Learning Trends, 1975.

Schultz, Gwen. *Icebergs and Their Voyages.* Caldwell, NJ: William Morrow and Co., Inc., 1975.

Schwartz, Frank J., and Jim Tyler. *Marine Fishes Common to North Carolina.* Raleigh, NC: North Carolina Department of Natural and Economic Resources, Division of Commercial and Sports Fisheries, 1970.

Soule, Gardner. *New Discoveries in Oceanography.* New York: G. P. Putnam's Sons, 1974.

U. S. Government. *Questions and Answers About the Oceans.* Washington, DC: U. S. Government Printing Office, 1968.

Verduin, Jacob. *Field Guide to Lakes.* ESCP Pamphlet Series No. 8. Boston: Houghton Mifflin Co., 1971 (pamphlet)

Voss, Gilbert L. *Oceanography: A Golden Guide.* New York: Western Publishing Co., Inc., 1972.

Science and the Sea: Part II

Segment Synopsis

In Part II of SCIENCE AND THE SEA, students watch scientists investigate the effects of pollution on sea life. A group of marine chemists sample the area to determine the existing levels of heavy metals and tritium. They use a pole sampler to prevent specimen contamination as they collect samples which might contain mercury, lead, copper and cadmium. They use a Nisken bottle to gather water required for tritium analysis, and an air sampler to compare the amount of mercury in the air with that found in the water.

One scientist collects fish and other marine life for the public aquarium on Skidaway Island. Students view the process of trawling and share the excitement of the biologists as they inspect their catch.

After the research is completed at the transect stations, the EASTWARD puts into the mouth of the Savannah River and many of the scientists go ashore. As the EASTWARD heads back to Beaufort, she detours for one day to Cape Fear off the coast of North Carolina. There she continues a mapping project to determine the origin of some recently discovered buried channels. Mapping data are collected by creating shock waves in the water using an air gun and recording the returning signals. The resulting seismic profiles are plotted and sites for bottom samples are selected. A rock dredge is then used at select spots to sample the walls of the channels. Because of limited time, only a portion of the work is completed and more mapping will be accomplished on later cruises.

Students watch the precision depth recorder which the EASTWARD operates while sailing. The instrument uses a transducer on the hull to send out a sound pulse which bounces off the bottom and is recorded as it returns to the surface. The record of the pulses is a profile of the depth and shape of the ocean bottom. Later these records will be combined with many others and used to construct oceanographic charts and other maps. The program comes to a close as the EASTWARD returns to port.

SPECIAL NOTE TO TEACHERS

Programs 15 and 16 are not designed to teach students the concepts of oceanography but rather give them a true picture of what life and work is like on an average oceanographic research vessel. No two cruises are alike and the array of instruments and investigations on research vessels changes from cruise to cruise. It is important for students to understand that oceanography, like many other sciences, is hard, tiring, and often boring work, but that it holds a particular kind of thrill for the scientific investigators.

Concepts

- Oceans are large bodies of water covering seventy percent of the earth's surface.
- Oceanography is a varied science employing many modern techniques to investigate the ocean.
- The ocean basins have characteristic topographic features.
- The topography of the ocean basins is as rugged and varied as that of the continents.

Objectives

After watching this program and completing appropriate follow-up activities, the student should be able to

- locate and name the major oceans of the world
- explain some of the methods used by modern oceanographers
- illustrate some of the major ocean bottom landforms.

Learning Activities

Using a world map which shows ocean bottom relief, have students construct a scaled cross-section of the Atlantic, from Cape Hatteras to Lisbon, Portugal, and of the 30th parallel, from Hang Shou, China to Baja, California.

Have students draw a cross-section of the North Carolina continental shelf, slope and Hatteras Abyssal Plain. See Plate No. 1 (page 3) in Newton, Pilkey, and Blanton's OCEANOGRAPHIC ATLAS OF THE CAROLINA CONTINENTAL MARGIN (1971), published by Duke University Marine Laboratory, Beaufort, North Carolina.

Media Resources

FILMS

BATHYMETRY: DISCOVERING THE OCEAN FLOOR - CHARTING THE OCEAN BOTTOM. 16mm. 16 min. sd. color. Dept. of the Navy, 1970.

THE EARTH BENEATH THE SEA. 16mm. 27 min. sd. color. Lamont Geological Observatory.

FLARE. 16mm. 14 min. sd. color. National Oceanic and Atmospheric Administration.

THE LAND BENEATH THE SEA. 16mm. 25 min. sd. color. Dept. of the Navy, 1967.

LAND OF THE SEA. 16mm. 28 1/2 min. sd. color. Dept. of the Navy.

MISSION: OCEANOGRAPHY. 16mm. 28 min. sd. color. Dept. of the Navy, 1966.

OCEAN DESERT. 16mm. 28 1/2 min. sd. color. Dept. of the Navy, 1971.

OCEAN INSTRUMENTS FOR DEEP SUBMERGENCE VEHICLES. 16mm. 29 min. sd. color. Dept. of the Navy, 1969.

OFFSHORE. 16mm. 18 min. sd. color. Modern Talking Picture Service.

SEA PROBE. 16mm. 17 min. sd. color. Modern Talking Picture Service.

SEA VENTURE. 16mm. 28 1/2 min. sd. color. Modern Talking Picture Service, 1972.

SIXTY DAYS BENEATH THE SEA: TEKTITE I 16mm. 14 1/2 min. sd. color. Dept. of the Navy, 1970.

SOUNDS IN THE SEA. 16mm. 28 min. sd. color. Dept. of the Navy, 1970.

UNDERSEA OASIS. 16mm. 29 min. sd. color. Shell Film Library, 1973.

FILMSTRIPS

AIR-SEA INTERACTION. 1 color filmstrip. disc recording. Ency. Britannica Ed. Corp.

BIOLOGICAL OCEANOGRAPHY. 1 color filmstrip. disc recording. Ency. Britannica Ed. Corp.

A CAREER IN OCEANOGRAPHY. 1 color filmstrip. disc recording. Ency. Britannica Ed. Corp.

GEOLOGICAL OCEANOGRAPHY. 1 color filmstrip. disc recording. Ency. Britannica Ed. Corp.

MARINE RESOURCES. 1 color filmstrip. disc recording. Ency. Britannica Ed. Corp.

CHARTS

Note: Physiographic Maps of the ocean floor are available from: The National Geographic Society, The Naval Oceanographic Office, and The Geological Society of America.

TRANSPARENCIES

OCEANOGRAPHY. 4 color transparencies. Hubbard Scientific Co.

OCEANOGRAPHY. 18 color transparencies. Hubbard Scientific Co.

POSTERS

MARINE FISHES OF THE GULF AND SOUTH ATLANTIC. 1973. Washington, DC: U. S. Government Printing Office.

MARINE FISHES OF THE NORTH ATLANTIC. 1971. Washington, DC: U. S. Government Printing Office.

Recknagel, John H. GENERAL PLANT AND ANIMAL RELATIONSHIPS IN THE OCEAN Suitland, MD: U. S. Naval Oceanographic Office.

SLIDES

WHAT ON EARTH? SLIDE SET 0/15-16.

Teacher References

Barber, Richard T., and Newton, John G. 1974. 1973-74 *Progress Report Duke University Oceanographic Program.* Beaufort, NC: Duke Univ. Marine Laboratory.

Church, Ron. 1971. Deepstar explores the ocean floor. *National Geographic* 139 (Jan.): 110-129.

Daniel, James E. *Carolina Marine Aquaria.* Burlington, NC: Carolina Biological Supply Co. (pamphlet)

Gordon, Bernard L., ed. 1972. *Man and the Sea: Classic Accounts of Marine Explorations.* Garden City, NY: Doubleday Natural History Press.

Hamner, William M. 1974. Blue Water Plankton: Ghosts of the Gulf Stream: *National Geographic* 146(Oct.): 530-545.

Moutvic, J. C. 1973. Pickle jar oceanography. *The Science Teacher* Nov.: 43.

National Oceanic and Atmospheric Administration. 1976. *National Ocean Survey Publications for Safe Navigation.* Washington, DC: U. S. Government Printing Office. (pamphlet)

Newton, J. G.; Pilkey, O. H.; and Blanton, J. O., 1971. *An Oceanographic Atlas of the Carolina Continental Margin.* Beaufort, NC: Duke Univ. Marine Laboratory.

Spotte, Stephen. 1973. *Marine Aquarium Keeping: The Science, Animals and Art.* New York: John Wiley and Sons, Inc.

U. S. Naval Oceanographic Office. 1967. *Science and the Sea.* Washington, DC: U. S. Government Printing Office. (pamphlet)

U. S. Navy Hydrographic Office. 1966. *Hydrography.* American Practical Navigation, Part 8. H. O. Pub. No. 9, Part 8. Washington, DC: U. S. Government Printing Office.

VanDerwalker, John G. 1971. Science's window on the sea. *National Geographic* 140 (Aug.): 256-289.

17

Land vs. Sea: The Interface

Man and the Sea
Waves
The Beach in Action

Program Overview

Natural changes occur along the interface of two different bodies. Weathering occurs at the molecular interface of rock and air or water. Metamorphism occurs when volcanic rock meets country rock. Squall lines of thunderstorms form at the interface of warm moist air and cool dry air. This program examines the changes that occur at two of the more easily observable interfaces, the meeting of the ocean waters and the atmosphere above and the meeting of the land and the sea. The first segment is a short film essay introducing students to the wind and the ocean. The second segment studies how waves are generated by the wind and the last segment explores how wave energy is expended on the shore.

Textbook References

- A SEARCH FOR UNDERSTANDING
    Ch. 10-5: Movements of the Oceans: Waves and Tides, pp. 314-319
    Ch. 10-7: The Shore Line, pp. 326-331
- MODERN EARTH SCIENCE
    Ch. 17: Motions of the Sea, pp. 352-374
- PATTERNS IN OUR ENVIRONMENTS
    No references
- THE WORLD WE LIVE IN
    Ch. 22: Waves and Shorelines, pp. 303-320
- EARTH SCIENCE: A LABORATORY APPROACH
    Ch. 10-5: Ocean Currents and the Land, pp. 231-232
    Ch. 10-6: Waves and Land Bodies, p. 233
- EARTH SCIENCE: IIS
    Idea 6-5: Beach Boys' Delight, pp. 221-224
- FOCUS ON EARTH SCIENCE
    Ch. 12-3: Ocean Waves, pp. 228-230
    Ch. 12-5: Shore Processes, pp. 235-239
    Ch. 12-6: Shore Deposits, pp. 239-247
- HOLT: EARTH SCIENCE
    Ch. 12: Motions of the Sea, pp. 342-367
    Ch. 3: Shaping the Land, pp. 64-95
- INVESTIGATING THE EARTH
    Ch. 4-4: Waves Carry Energy, pp. 84-88
    Ch. 4-5: Winds Cause Currents at the Ocean's Surface, pp. 88-90
- OUR ENVIRONMENT IN SPACE
    Ch. 15: Energy Exchanges Within the Oceans, pp. 299-319
    Ch. 19: Work of Waves and Tides Upon the Shore, pp. 393-402

- PATHWAYS IN SCIENCE
  VI Ch. 4: The Restless Ocean Waters,
  pp. 310-315

Student Readings

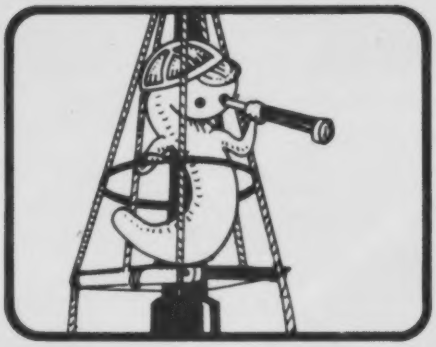
Adams, George F., and Jerome Wyckoff. *Landforms.* New York: Western Publishing Co., Inc., 1971.

Britton, Peter. "Nightware Waves are all too Real to Deepwater Sailor." *Smithsonian*, Feb. 1978, pp. 60-67.

Hoyt, J. H. *Field Guide to Beaches.* ESCP Pamphlet Series No. 7. Boston: Houghton Mifflin Co., 1971.

Rhodes, Frank. *Geology.* New York: Western Publishing Co., Inc., 1971.

Voss, Gilbert L. *Oceanography.* New York: Western Publishing Co., Inc., 1972.



Man and the Sea

Segment Synopsis

The days of the sailing ship are past but around the world a few clippers still sail. The sailing ship, EAGLE, is used by the U. S. Coast Guard Academy for training purposes. With music of the sea, this two-minute voyage gives students a brief taste of the days when wind was the principal power for ships and the clippers were queens of the ocean.

Concept

- Man has made use of the sea in many ways.

Objective

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain one or more ways in which mankind has derived benefits from the sea.

Learning Activities

Have students prepare reports or displays on how man has used the sea for transportation, communication, commerce, war, and recreation throughout history.

Have students write poems about the sea's effect on man.

Plan an art contest with The Sea as a central theme.

Media Resources

FILMS

THE SEA. 16mm. 28 1/2 min. sd. color.
National Film Board of Canada, 1971.

OCEAN. 16mm. 10 min. sd. color.
Pyramid Films.

SEASHORE. 16mm. 8 min. sd. color.
Pyramid Films.

Teacher Reference

Villiers, Alan, et al. 1973. *Men, Ships, and the Sea*. Washington, DC: National Geographic Society.

Waves

Segment Synopsis

The student visiting the coast for the first time is impressed by waves and surf along the beach but he seldom relates them to the meeting of wind and and water. This segment begins by discussing waves generated by the wind. Through high speed photography, students see waves form and grow into ripples and swells. Then students follow the waves as they move and eventually expend their energy as breakers on the shore.

Concepts

- Ocean waves acquire kinetic energy from the wind.
- Ocean waves and tides are forms of basic wave phenomena.
- Waves are affected by the depth of water in which they are moving.
- Waves ultimately transfer energy to the land's edge.
- Ocean waves concentrate energy at the coastlines of the world.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- define a wave and identify its parts
- explain how waves are formed by wind acting at the ocean's surface
- explain and illustrate the breaking process of waves.

Learning Activities

Before viewing this segment, students should understand the following terms: wave, height, speed, trough, crest, period, breaker.

Have students prepare displays illustrating one or more of the following topics: parts of a wave, how waves form, why a wave breaks, surf beat.

Have students prepare and present reports on waves, tsunami, and tides, showing how they differ from each other.

Have students use a fan to produce wind on a long pan of water to study the effects of wind speed, duration, and fetch on wave size.

Tie a rope to a fixed point and create waves by moving the free end. Mark a point near the middle of the rope. Discuss the kind of waves formed and how the point moves.

Have students mount a grid on the side of an aquariam or wave tank and use it to study waves generated in the tank. The waves can be studied by floating wood chips and observing how they move, or by attaching pith balls to a piece of string anchored to the tank's bottom and watching wave movement reflected in the balls. Features to be studied should include wave length, period, height, speed, and orbital motion.

Build a slope in a wave tank and study the behavior of waves breaking on the slope.

Media Resources

FILMS

WAVES ON WATER. 16mm. 16 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

TSUNAMI. 16mm. 28 min. sd. color. National Oceanic and Atmospheric Administration.

OCEAN TIDES. 16mm. 14 min. sd. color. Ency. Britannica Ed. Corp. (Bay of Fundy)

FILM LOOP

WATER WAVES. 1 color film loop. Ency. Britannica Ed. Corp.

SLIDES

WHAT ON EARTH? SLIDE SET 0/17/2

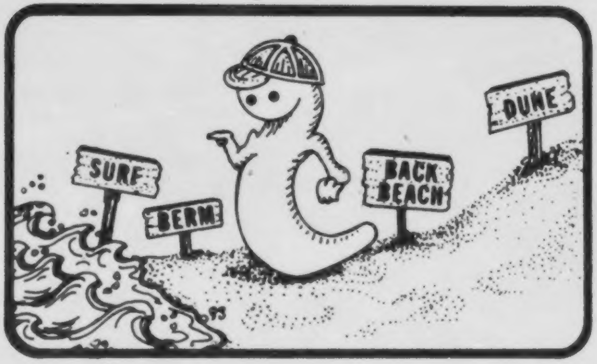
Teacher References

Bascom, Willard. 1959. Ocean waves. *Scientific American* 201(Aug.): 29, 74-84.

Bascom, Willard. 1964. *Waves and Beaches: The Dynamics of the Ocean Surface.* New York: Doubleday and Co., Inc.

National Oceanic and Atmospheric Administration. *Our Restless Tides.* Washington, DC: U. S. Government Printing Office.

17-3



The Beach in Action

Segment Synopsis

The beach is the interface between water and land. In THE BEACH IN ACTION, students take a walking tour of this interface, looking at its features, beauty, and dangers. The structure of summer and winter beach profiles is discussed along with rip currents, sand transport, off shore bars, long shore currents, and the conversion of rocky herdlands to sandy beaches. The walk closes by suggesting that the processes at work on the beach cause problems for man when he tries to live along the shore.

Concepts

- Ocean waves acquire kinetic energy from the wind.
- Ocean waves and tides are forms of basic wave phenomena.
- Waves ultimately transfer energy to the land's edge.
- Ocean waves concentrate energy at the coastlines of the world.
- Landscapes are constantly changing.
- At any scale of observation, landscapes may be divided into those areas losing material and those receiving material.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain and illustrate the breaking process of waves
- explain and illustrate how wave energy is distributed along a coastline
- identify the major types of coastline features occurring on a sand beach
- explain the concept of change as it applies to coastal landforms
- explain and illustrate the formation and destruction of various coastal landforms on a sand beach.

Learning Activities

Before viewing this segment, students should understand the following terms: surf, fore shore, berm, back beach, fore (primary) dune.

Have students prepare displays illustrating one or more of the following topics: seasonal beach profiles, beach features in a profile, off shore bars, long shore currents.

Have students set up a stream table and generate waves to form a typical beach profile for a straight beach. Modify the beach to cause waves to strike obliquely and then study how the waves transport the sand. Have students create an irregular shoreline and study the actions of the waves upon it.

Have students construct an exhibit showing how a rip current develops and what they should do if they are caught in one.

Students who live near the coast or a large lake should actually profile their beach. They might want to introduce colored marker sand onto the beach and trace its movement.

Media Resources

FILM

THE BEACH: A RIVER OF SAND. 16mm. 21 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

SLIDES

WHAT ON EARTH? SLIDE SET 0/17/3.

Teacher References

Baker, Simon. 1977. *The Citizen's Guide to North Carolina's Shifting Inlets.* Raleigh, NC: UNC Sea Grant Publication.

Bascom, Willard. 1964. *Waves and Beaches: The Dynamics of the Ocean Surface.* New York: Doubleday and Co., Inc.

Exline, Joseph D. 1975. *Individualized Techniques for Teaching Earth Science.* Englewood Cliffs, NJ: Prentice-Hall, Inc.

18

Land Meets Sea

Shorelines Around the World
A Naturalist Looks at the Outer Banks

Program Overview

Program Eighteen continues the exploration of the land - sea interface begun in Program Seventeen. This program looks first at the types of coastlines that result when various landforms meet the pounding surf. In the second segment, a marine biologist looks at the living systems along the shore and relates them to the ever-changing coastal interface.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 10-7: The Shoreline, pp. 326-331
- MODERN EARTH SCIENCE
  - Ch. 14: Shorelines, pp. 296-313
- PATTERNS IN OUR ENVIRONMENT
  - No references
- THE WORLD WE LIVE IN
  - Ch. 22: Waves and Shorelines, pp. 303-320
- EARTH SCIENCE: A LABORATORY APPROACH
  - No references
- EARTH SCIENCE: IIS
  - No references
- FOCUS ON EARTH SCIENCE
  - Ch. 12-5: Shore Processes, pp. 235-238
  - Ch. 12-6: Shore Deposits, pp. 239-247
- HOLT: EARTH SCIENCE
  - Ch. 3: Shaping the Land, pp. 43-62
- INVESTIGATING THE EARTH
  - Ch. 10-7: The Shorelines Have Moved, pp. 226-228
- OUR ENVIRONMENT SPACE
  - Ch. 19: Work of Waves and Tides Upon the Shore, pp. 402-408
- PATHWAYS IN SCIENCE
  - No references

Student Readings

Adams, George F., and Jerome Wyckoff. *Landforms.* New York: Western Publishing Co., Inc., 1971.

Brokaw, Dennis, and Wesley Marx. *The Pacific Shore: Meeting Place of Man and Nature.* New York: E. P. Dutton and Co., Inc., 1974.

Carson, Rachel. *The Edge of the Sea.* Boston: Houghton Mifflin Co., 1955.

Colton, F. Barrows. "Mountains Top Off New England." *National Geographic,* May 1951, pp. 563-602.

Ellis, William S. "Lonely Cape Hatteras, Besieged by the Sea." *National Geographic,* Sept. 1969, pp. 392-421.

Pringle, Laurence. *Estuaries: Where Rivers Meets the Sea.* New York: Macmillan Publishing Co., Inc. 1973.

Porter, Hugh J., and Jim Tyler. *Sea Shells Common to North Carolina.* Raleigh, NC: Dept. Natural and Economic Resources, Division of Commercial Sports Fisheries, 1971.

Rhodes, Frank. *Geology.* New York: Western Publishing Co., Inc., 1971.

Robert, Bruce, and David Stick. *Cape Hatteras Seashore.* Santa Barbara, CA: McNally and Loftin, 1964.

Scofield, John. "Character Marks the Coast of Maine." *National Geographic,* June 1968, pp. 798-843.

Teal, John, and Mildred Teal. *Life and Death of a Salt Marsh.* New York: Ballentine Books, Inc., 1974.

Zahl, Paul A. "Oregon's Sidewalk on the Sea." *National Geographic,* Nov. 1961, pp. 708-734.

18-1

Shorelines Around the World

Segment Synopsis

Shorelines around the world vary widely in their history and appearance. Traveling from Maine to Alaska, Hawaii, California, Mississippi, and finally North Carolina, this segment illustrates the different types of shorelines that exist. Submergent, emergent, and neutral forms are considered along with volcanic, faulted, and glacial forms. The segment closes with a look at the barrier island as a shoreline, stressing that this is only one of several kinds of shorelines.

Concepts

- Waves ultimately transfer energy to the land's edge.
- Ocean waves concentrate energy at the coastlines of the world.
- Landscapes are constantly changing.
- At any scale of observation, landscapes may be divided into those areas losing material and those receiving material.
- Landforms at the sea's edge are a product of wave and current action on a rising, sinking, or neutral land surface.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain and illustrate how wave energy is distributed along a coastline
- identify the major types of coastline features
- explain the concept of change as it applies to coastal landforms
- explain and illustrate the formation and destruction of various coastal landforms
- predict some effects of changing coastal forms on particular areas.

Learning Activities

Before viewing this segment students should understand the following terms: emergent shoreline, submergent shoreline, barrier islands.

Have students create posters advertising various coastlines around the world.

Have students study maps and air photos of typical submergent and emergent shorelines.

Have students view a series of slides showing various coastlines and decide which type of land -sea relationship exists for each.

Media Resources

FILMS

MARINE EROSION PROCESSES: CLIFFED COASTS. 16mm. 11 min. sd. color. Macmillan Films.

THE EARTH: COASTLINES. 16mm. 11 min. sd. color. Coronet Films, 1969.

FILM LOOPS

COASTAL PLAINS: PARTS I AND II. 2 color film loops. Hubbard Scientific Co.

COASTLINE. PARTS I AND II. 2 color film loops. Hubbard Scientific Co.

WATER ECOSYSTEMS. 6 color film loops. Hubbard Scientific Co.

SLIDES

WHAT ON EARTH? SLIDE SET 0/18/1.

WATER EROSION AND DEPOSITION. 20 color slides. Hubbard Scientific Co.

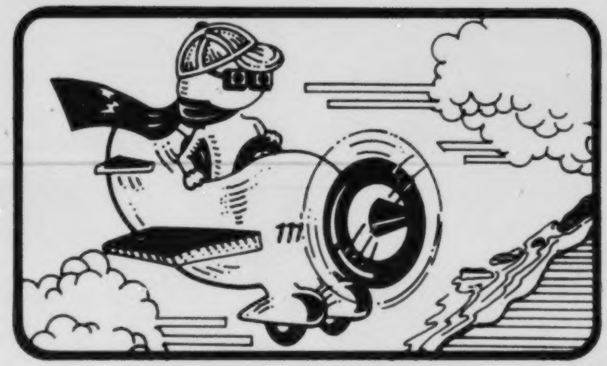
EROSIONAL FEATURES. 20 color slides. Hubbard Scientific Co. (from the Landform Features slides)

Teacher References

Farmer, Francis; Brower, David; and Frankenberg, Dirk. 1976. *Ecological Determinants of Coastal Area Management*. V. 11, An Overview. Raleigh, NC: UNC Sea Grant Publication.

Katauan, Michael P., and Ingram, Roy L. 1974. *Sedimentary Structures of a Modern Lagoonal Environment*. Pamlico Sound, North Carolina. Raleigh, NC: UNC Sea Grant Publication.

Riggs, S. R., and O'Connor, M. P. 1974. *Relict Sediment Deposits in a Major Transgressive Coastal System*. Raleigh, NC: UNC Sea Grant Publication.



A Naturalist Looks at the Outer Banks

Segment Synopsis

Judy Spitzbergen, a marine biologist, walks along the beach of Shackleford Banks, N. C. and discusses this unique barrier island and its relationship to the other islands of Carolina's Outer Banks. She tours the island and shows students the living systems that exist from shore to salt marsh and sound. Ms. Spitzbergen also focuses on the fragile nature of the system and the transient nature of the islands.

Concepts

- Landscapes are constantly changing.
- At any scale of observation, landscapes may be divided into those areas losing material and those receiving material.
- Barrier islands are formed by wave, wind, and current action on a sinking coastline.
- Plant communities living on barrier islands reflect the changing physical conditions of their environment.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- identify the major types of coastline features found on a barrier island
- explain the concept of change as it applies to a barrier island
- explain and illustrate the formation and destruction of various landforms that exist on a barrier island
- explain how plant communities respond to changes on a barrier island and identify the possible types of plants that grow on the islands.

Learning Activities

Prior to viewing this segment students should understand the following terms: beach, foredune, sand sea, maritime forest, salt marsh, sound, washover.

Have students prepare a display illustrating various types of biological systems which may exist on a barrier island.

Have students build a model of a typical barrier island and use it as the center of a display explaining how wind and water cause the island to shift.

Media Resources

FILMS

BEACH AND SEA ANIMALS. 16mm. 11 min. sd. color. Ency. Britannica Ed. Corp.

BILLION DOLLAR MARSH. 16mm. 44 min. sd. color. Time-Life Inc.

CRISIS IN THE ESTUARY. 16mm. 15 min. sd. color. Milner-Fenwick, Inc.

ESTUARINE HERITAGE. 16mm. 28 min. sd. color. National Oceanic and Atmospheric Administration.

ESTUARY. 16mm. 28 min. sd. color. Modern Talking Pictures.

LIFE BETWEEN THE TIDES. 16mm. 11 min. sd. color. Ency. Britannica Ed. Corp.

THE SALT MARSH: A QUESTION OF VALUES. 16mm. 22 min. sd. color. Ency. Britannica Ed. Corp.

SALT MARSHES: BARRIER BETWEEN SEA AND LAND. 16mm. 24 min. sd. color. Harper and Row.

SEASHORE LIFE. 16mm. 10 min. sd. color. Ency. Britannica Ed. Corp.

SLIDES

WHAT ON EARTH? SLIDE SET 0/18/2.

Teacher References

Bascom, Willard. 1960. Beaches. *Scientific American* 203(Aug): 32, 80-92.

Graetz, Karl E. 1973. *Seacoast Plants of the Carolinas for Conservation and Beautification.* Raleigh, NC: U. S. Dept. of Agriculture, Soil Conservation Service.

Pilky, Orin H., Jr.; Pilky, Orin H., Sr.; and Turner, Robb. 1975. *How to Live With an Island, a Handbook to Boque Banks North Carolina.* Raleigh, NC: N. C. Dept. of Natural and Economic Resources.

Silberhorn, Gene M. 1976. *Tidal Wetland Plants of Virginia.* Ed. Series No. 19. Gloucester, Point, VA: Institute of Marine Sciences.

U. S. Geological Survey. 1975. *Submerged and Emerged Coastal Plain Province, Cape Lookout Area, North Carolina.* Washington, DC: U. S. Geological Survey.

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Man and the Sea

Wind and Sand
The Beach is a Very Special Place

Program Overview

This program concludes the five program sequence dealing with oceanography and shore processes. It seems appropriate that the segments in this program look at the inevitable motion of the Atlantic Coast barrier islands and with man's efforts to change nature. Segment One studies the nature of sand and its behavior. Segment Two examines how man has used the coastal lands.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 7-1: Wind Deposits, pp. 209-214
  - Ch. 20-1: Using Your Knowledge of Earth Science in Making Environmental Choices, pp. 646-651
  - Ch. 20-4: Some Other Factors In Making Environmental Choices, pp. 662-665
- MODERN EARTH SCIENCE
  - Ch. 11: Weathering and Erosion, pp. 232-252
  - Ch. 24: Upsetting Nature's Balance, pp. 504-521
- PATTERNS IN OUR ENVIRONMENT
  - No references
- THE WORLD WE LIVE IN
  - Ch. 9: Wind, pp. 122-129
- EARTH SCIENCE: A LABORATORY APPROACH
  - Ch. 7-4: Erosion and Deposition by the Wind, pp. 141-144
  - Ch. 7-5: Sand Dunes and Other Landforms Created by Wind Action, pp. 145-146
- EARTH SCIENCE: IIS
  - Idea 7-4: A Cloud of Dust and a Hearty Cough, pp. 255-258
- FOCUS ON EARTH SCIENCE
  - Ch. 16: Wind, pp. 306-317
- HOLT: EARTH SCIENCE
  - Ch. 3: Shaping the Earth, pp. 64-95
- INVESTIGATING THE EARTH
  - Ch. 9-9: Water, Ice and Wind Erode the Land, pp. 203-206
- OUR ENVIRONMENT IN SPACE
  - Ch. 20: Work of Winds Upon the Land, pp. 419-435
- PATHWAYS IN SCIENCE
  - II Ch. 5: Wind and Water Change the Earth's Surface, pp. 93-97
  - VI Ch. 1: The Earth's Waters, pp. 292-298
  - VI Ch. 2: The Nature of Ocean Water, pp. 299-303
  - VI Ch. 5: The Citizens of the Ocean, pp. 316-322

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Student Readings

Adams, George F., and Jerome Wyckoff. *Landforms.* New York: Western Publishing Co., Inc., 1971.

Amos, William H. "The Living Sand." *National Geographic*, June 1965, pp. 820-833.

Jurgensen, K. M. *Know Your Mud, Sand and Water: A Practical Guide to Coastal Development.* Raleigh, NC: UNC Sea Grant Publication, 1976. (pamphlet)

Kenney, Nathaniel T. "Our Changing Atlantic Coastline." *National Geographic*, Dec. 1962, pp. 860-887.

McNeil, Ben Dixon. *The Hatterasman.* Winston-Salem, NC: John F. Blair, 1958.

Rhodes, Frank. *Geology.* New York: Western Publishing Co., Inc., 1971.

Seltz, Johanna. *The Dune Book: How To Plant Grasses for Dune Stabilization.* Raleigh, NC: UNC Sea Grant Publication, 1976. (pamphlet)

Stick, David. *Graveyard of the Atlantic.* Chapel Hill, NC: Univ. of North Carolina Press, 1952.

Time-Life Editors. *The American Wilderness.* Morristown, NJ: Silver Burdett Co., 1972-74. (a series of 22 titles about special environments).

Wind and Sand

Segment Synopsis

WIND AND SAND describes how wind affects the sands of coastal lands. It examines the character of sand and its transportation by the wind. The segment also illustrates dune formation, movement, and cross bedding.

Concepts

- Landscapes are constantly changing.
- At any scale of observation, landscapes may be divided into those areas losing material and those receiving material.
- Wind action of loose materials creates a unique set of landforms.
- Wind-related landforms affect man's activities in any area where they exist.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- identify the major types of wind-formed features
- explain the concept of change as it applies to wind-created landforms
- explain and illustrate the formation and destruction of various wind-created landforms.
- predict some effects of changing wind-created forms on particular areas.

Learning Activities

Before viewing this segment students should know the meaning of the following terms: sand, dune, saltation, cross bedding, barchan, sand sea.

Have students prepare a display, research paper, or oral presentation explaining how deserts form around the world. Other possible topics include kinds of dunes, how dunes form, and how dunes move.

Have students prepare a display showing how sand grains reflect their origin and history.

Students in sandy regions may wish to plant holding grasses or erect sand fences to study the effect of these measures on erosion.

Have students demonstrate the process of saltation. Use a fan or vacuum cleaner to blow air on a sand pile and observe the results.

Media Resources

FILMS

SAND. 16mm. 10 min. sd. color. Pyramid Films.

DUNES. 16mm. 7 min. sd. color. Pyramid Films.

SAND: THE DESERT IN MOTION. 16mm. 11 min. sd. color. BFA Educational Media.

SLIDES

WHAT ON EARTH? SLIDE SET 0/19/1.

EROSIONAL FEATURES. 20 color slides. Hubbard Scientific Co.

WIND EROSION AND DEPOSITION. 20 color slides. Hubbard Scientific Co.

Teacher References

Findley, Rowe. 1970. Death Valley, the land and the legend. *National Geographic* 137(Jan.): 63-103.

Woodhouse, W. W., Jr.; Seneca, E. D.; and Broome, S. W. 1976. *Ten Years of Development of Man-Initiated Coastal Barrier Dunes in North Carolina.* Bulletin 453. Raleigh, NC: Agricultural Experiment Station, N. C. State Univ.

The Beach is a Very Special Place

Segment Synopsis

This segment traces man's activities on the barrier islands and sounds of the Carolinas from early colonization to the present. An effort is made to build a picture of the effects of man's activities on the coastal zone and to show what has happened as a result of increased use and misuse. The segment closes by suggesting that each student will have to help make decisions that will decide the destiny of the coastal lands--a destiny caught up in a battle between man and the sea.

Concepts

- Man's efforts to control shorelines must respect natural processes.
- Landforms at the sea's edge are a product of wave and current action on a rising, sinking, or neutral land surface.
- At any scale of observation, landscapes may be divided into those areas losing material and those receiving material.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain the concept of change as it applies to coastal landforms
- explain and illustrate the formation and destruction of various coastal landforms
- predict some effects of man's efforts to change coastal forms in particular areas.

Learning Activities

Have students organize a class debate analyzing the pros and cons of coastal development.

Before viewing this segment students may wish to research the effects of storms on developed beach areas by reading accounts of storms in back issues of newspapers and magazines.

Organize a poster contest promoting the protection of barrier islands and other natural resources and the preservation of existing natural areas in the United States.

Have students choose a particular coastal area, research the effect of development on its shoreline erosion, and decide on a course of action to correct any damage.

Media Resources

FILMS

THE NEW JERSEY SHORELINE. 16mm. 18 min. sd. color. Environmental Films Inc.

MEN AT BAY. 16mm. 25 1/2 min. sd. color. King Screen Production.

SLIDES

WHAT ON EARTH? SLIDE SET 0/19/2

Teacher References

Hitchcock, Stephen. W. 1972. Can we save our salt marshes? *National Geographic* 141(June): 729-765.

Owens, David W., and Brower, David J., 1976. *Public Use of Coastal Beaches*, Raleigh NC: UNC Sea Grant Publication (pamphlet)

Pilky, Orrin H., Jr.; Pilky, Orrin, H., Sr.; and Turner, Robb. 1975. *How to Live with an Island, A Handbook to Boque Banks, North Carolina*. Raleigh, NC: N. C. Dept. of Natural and Economic Resources.

Rasmussen, Frederick A., and RDD Consultants. 1978. *Coastal Awareness: A Resource Guide for Teachers in Elementary Science*. Washington, DC: Office of Coastal Zone Management, National Oceanic and Atmospheric Administration.

Unit 4

Geology

The phenomena related to the solid earth are the topics for Programs 20 through 29. Program 20 is devoted to minerals, first as crystals and second as collectible objects. Programs 21 through 24 explore phenomena that result in land building: the rock cycle, the theory of plate tectonics, folding, faulting, and earthquakes, and the landforms and rock types produced by igneous and metamorphic processes. Programs 25, 26, and 27 consider processes that wear down the rocks of the crust through physical and chemical weathering: stream erosion, glacial erosion, underground water, and the formation of sedimentary rocks. Program 28 combines many of the major ideas from earlier programs to trace the life cycles of mountains, plains, and plateaus. Program 29 closes the geology sequence and the entire series by considering the vast expanse of geologic time.

Throughout, the geology programs portray the earth as a special place in which man is a relative newcomer with a unique role to play. Students are encouraged to view themselves as stewards of the earth with major responsibilities to protect the planet for future generations.

References

BOOKS

Bailey, Sir Edward. 1963. *Charles Lyell.* Garden City, NY: Doubleday and Co., Inc.

Berry, Leonard G., and Mason, Brian. 1959. *Mineralogy--Concepts, Descriptions, Determinations.* San Francisco: W. H. Freeman and Co.

Blatt, Harvey; Middleton, Garard; and Murry,Raymond. 1972. *Origin of Sedimentary Rocks.* Englewood Cliffs, NJ: Prentice-Hall, Inc.

Bullard, Fred M. 1976. *Volcanoes of the Earth.* rev. ed. Austin: Univ. of Texas Press.

Dunbar, Carl O., and Waage, Karl M. 1969. *Historical Geology.* 3rd ed. New York: John Wiley and Sons, Inc.

Holmes, Arthur. 1965. *Principles of Physical Geography.* New York: Ronald Press Co.

Hunt, Charles B. 1974. *Natural Regions of the United States and Canada.* San Francisco: W. H. Freeman and Co.

Leopold, Luna A. 1974. *Water--A Primer.* San Francisco: W. H. Freeman and Co.

MacDonald, Gordon A. 1972. *Volcanoes.* Englewood Cliffs, NJ: Prentice-Hall, Inc.

Pirsson, Louis V., and Knopf, Adolph. 1953. *Rocks and Rock Minerals.* 3rd ed. New York: John Wiley and Sons, Inc.

Seyfert, Carl K., and Sirkin, Leslie A. 1973. *Earth History and Plate Tectonics: An Introduction to Historical Geology.* New York: Harper and Row.

Strahler, Arthur N. 1971. *Earth Science.* 2nd ed. New York: Harper and Row.

____________. 1975. *Physical Geography.* 4th ed. New York: John Wiley and Sons, Inc.

Thornbury, William D. 1969. *Principles of Geomorphology.* 2nd ed. New York: John Wiley and Sons, Inc.

U. S. Geological Survey. *Teacher's Packet for Secondary School Teachers.* Reston, VA: Geological Inquiries Group, U.S.G.S.

PERIODICALS

EARTH SCIENCE. bimonthly.

ROCKS AND MINERALS. monthly.

GEMS AND MINERALS. monthly.

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Minerals and Man

The Magic of Minerals
James Dana: Father of Mineralogy
What's a Rockhound?

Program Overview

The world of minerals is a science as well as an exciting hobby for many. This program begins with an exploration of the way minerals are formed and the properties that result from crystal structure and growth. It traces the history of the science and describes the aura of mystery surrounding certain famous stones. The second segment chronicles the life of James Dana, who is considered to be the Father of Mineralogy. In the final portion, students meet a rockhound. Jim Irvine explains his hobby and its rewards, he demonstrates several simple mineral identification techniques.

Textbook References

- A SEARCH FOR UNDERSTANDING
    - Ch. 3-1: Elements of the Crust, pp. 84-89
    - Ch. 3-2: Some Ways of Identifying Common Minerals, pp. 89-98
    - Ch. 3-3: The Shapes of Common Minerals, pp. 98-102
    - Ch. 3-4: The Specific Gravity of Minerals, pp. 102-105
- MODERN EARTH SCIENCE
    - Ch. 7: Earth Chemistry, pp. 138-152
    - Ch. 8: Materials of the Earth's Crust, pp. 153-181
- PATTERNS IN OUR ENVIRONMENT
    - Ch. 5-1: Earth Materials, Common and Uncommon, p. 112
    - Ch. 5-4: Properties of Minerals, pp. 113-114
    - Ch. 5-5: Determining the Hardness of Minerals, p. 115-116
    - Ch. 5-6: Other Properties of Minerals, p. 116
    - Ch. 5-7: Minerals That Make Up the Common Rocks in the Earth's Crust, pp. 117-118
- THE WORLD WE LIVE IN
    - Ch. 2: The Nature of Minerals, pp. 9-20
    - Ch. 3: Identifying the Rock Forming Minerals, pp. 21-35
- EARTH SCIENCE: A LABORATORY APPROACH
    - Ch. 8-2: Sorting of Earth Materials During Cooling and Hardening, pp. 164-165
- EARTH SCIENCE: IIS
    - Idea 3-2: Minerals Carry ID Cards, pp. 85-88
    - Idea 3-3: A Squeaky Experience, pp. 89-92
    - Idea 3-4: If It Itches, Scratch It, pp. 93-96
    - Idea 3-5: The New Wet Look, pp. 97-102
    - Idea 3-6: That's the Breaks, pp. 103-104
- FOCUS ON EARTH SCIENCE
    - Ch. 3: Matter, pp. 44-62
    - Ch. 4-1: Minerals, pp. 63-70
    - Ch. 4-2: Identification of Minerals, pp. 71-83

- HOLT: EARTH SCIENCE
    Ch. 5: Minerals, pp. 132-152
- INVESTIGATING THE EARTH
    Ch. 2: Earth and Moon Materials, pp. 26-48
- OUR ENVIRONMENT IN SPACE
    Ch. 4: Realms of Matter, pp. 64-66
- PATHWAYS IN SCIENCE
    I Ch. 6: Minerals Are Different From Rocks, pp. 30-35
    I Ch. 7: Following the Trails of Minerals, pp. 36-40

Student Readings

Arem, Joel E. *Man-Made Crystals.* Washington, DC: Smithsonian Institution Press, 1974.

Berry, James. *Exploring Crystals.* New York: Macmillan Publishing Co., Inc., 1969.

Boltin, Lee, and John White. *Color Underground: The Mineral Picture Book.* New York: Charles Scribner's Sons, 1971.

__________. *Gems in the Smithsonian Institution.* new ed. Washington: DC: Smithsonian Institution Press, 1972.

Desautels, Paul E. *Mineral Kingdom.* New York: Grosset and Dunlap, Inc., 1968.

__________. *The Gem Kingdom.* New York: Random House, 1971.

__________. *Gems in the Smithsonian Institution.* new ed. Washington, DC: Smithsonian Institution Press, 1972.

Holden, Alan, and Phyllis Singer. *Crystals and Crystal Growing.* Garden City, NY: Doubleday and Co., Inc., 1960.

Hurlburt, Cornelius, Jr. *Minerals and Man.* New York: Random House, 1975.

Jones, Robert W. "Minerals of the Southwest." *Arizona Highways,* 48 No. 5(1972), 12-33.

Pearl, Richard M. *Wonders of Gems.* New York: Dodd, Mead and Co., 1963.

__________. *1001 Questions and Answers About the Mineral Kingdom.* New York: Dodd, Mead and Co., 1968.

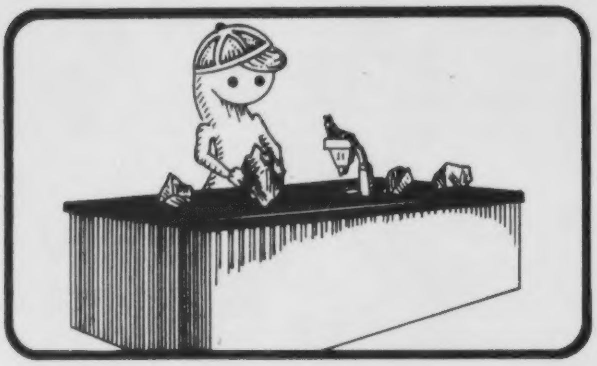
Sinkankas, John. *Gemstones and Minerals, How and Where to Find Them.* New York: D. Van Nostrand Co., 1961.

Sorrell, Charles A. *Minerals of the World.* New York: Western Publishing Co., Inc., 1974.

Wohlrabe, Raymond A. *Crystals.* New York: J. B. Lippincott Co., 1962.

Zim, Herbert S., and Paul R. Shaffer. *Rocks and Minerals.* New York: Western Publishing Co., Inc., 1959.

20-1



The Magic of Minerals

Segment Synopsis

THE MAGIC OF MINERALS introduces students to the science of mineralogy. The segment traces the history of man's knowledge of minerals, from the folklore of primitive man to the development of Dana's system of mineralogy in 1854. Special emphasis is given to the mystery surrounding the famous Hope Diamond and other "precious" stones. The segment then focuses on the growth and structure of crystals. It introduces the unit cell as the basic unit of crystalline structure. By means of special photography, students watch crystals growing from a melt. They see that crystals have planes, axes, and centers of symmetry. The six basic crystals are considered in turn, beginning with isometric and moving through tetragonal to orthorhombic, hexagonal, monoclinic, and triclinic. In each case the system's symmetry is illustrated with a model, followed by actual mineral examples. The segment concludes with a series of specimens illustrating various unusual growth habits.

Concepts

- Earth materials behave according to basic natural laws.
- The physical properties of earth materials are determined by the kind and arrangement of atoms comprising them.
- Crystals are orderly arrangements of atoms and exhibit relatively uniform properties.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- define the term mineral
- explain how crystals grow and illustrate the six basic crystal systems with appropriate modes of symmetry.

Learning Activities

Have students make a display showing the common rock forming minerals. Include each mineral's chemistry, crystal structure, and commercial uses.

Have students prepare posters illustrating some facts of the science of mineralogy or depicting the lives of famous mineralogists. (See Segment 2)

If this segment is used for review purposes, have students prepare displays or posters illustrating the six crystal systems, symmetry, the unit cell, crystal growing, or unusual growth habits.

Have students conduct #2-4: "Investigating Mass, Volume and Density" investigation from Miles F. Harris's,et al. Earth Science Curriculum Project textbook INVESTIGATING THE EARTH (1973), published by Houghton Mifflin Company, Boston, Massachusetts.

Have students design and carry out their own experiments in crystal growing.

Set up a cooperative project with math, art, and science teachers to have students build large crystal lattice models.

Media Resources

FILM

EARTH SCIENCE: MINERALS AND ROCKS. 16mm. 17 min. sd. color. Indiana Univ. Film Library, 1967.

FILM LOOP

MINERAL STRUCTURE. 1 color film loop. Hubbard Scientific Co.

SLIDES

WHAT ON EARTH? SLIDE SET G/20/1.

KITS

ABRIDGED GUIDE CRYSTALOGRAPHIC MODEL CONSTRUCTION KIT. 15 heavy paper models. Ward's Natural Science Establishment, Inc.

MOLECULAR MODEL KIT. a collection of spheres and connectors. Hubbard Scientific Co.

MODELS

WARD'S CELLULOID CRYSTAL MODELS. 6 crystal models. Ward's Natural Science Establishment, Inc.

LATTICE MODELS. models of atoms arranged in a solid. Ward's Natural Science Establishment, Inc.

Teacher References

Berry, Leonard G., and Mason, Brian. 1959. *Mineralogy: Concepts, Descriptions, Determinations.* San Francisco: W. H. Freeman and Co.

Hurlbut, Cornel, Jr., and Klein, Cornelius. 1977. *Manual of Mineralogy After J. D. Dana.* 19th ed. New York: John Wiley and Sons, Inc.

Rapp, G. 1971. *Color of Minerals.* ESCP Pamphlet Series No. 6. Boston: Houghton Mifflin Co.

Sinkankas, John. 1966. *Mineralogy: A First Course.* New York: Van Nostrand Reinhold Co.

White, Peter T. 1974. Gold, the eternal treasure. *National Geographic* 145(Jan.): 1-51.

Zahl, Paul A. 1977. Amber: golden window on the past. *National Geographic* 152 (Sept.): 423-435.

James Dana: Father of Mineralogy

Segment Synopsis

Few individuals have influenced a branch of science as profoundly as James Dwight Dana. This segment traces Dana's life and work, beginning with his birth in the village of Utica, New York, in 1813. It highlights his adventures as a student, teacher of mid-shipmen, explorer, and teacher. Special attention is given not only to Dana's development of the first systematic treatment of mineral classification but to the time period in which he worked.

Concepts

- Man's mind is his most important tool for investigating the earth.
- Man's senses are used to make observations; his mind, to interpret observations.
- The physical properties of earth materials are determined by the kind and arrangement of atoms comprising them.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain how James Dana applied his senses to interpret the basic properties of earth materials
- give examples of ways in which the physical properties of minerals are interpreted by man's senses.

Learning Activities

Have students try to group minerals according to different criteria such as size, color, and general shape.

Have students read biographies of James Dana and other famous scientists.

Have students research early mineral ideas and theories.

Have students construct displays highlighting James Dana's life and work.

Have students prepare displays illustrating early beliefs about the properties of minerals.

Media Resources

SLIDES

WHAT ON EARTH? SLIDE SET G/20/2.

Teacher References

Boyer, David S. 1974. The glittering world of rockhounds. *National Geographic* 145(Feb.): 276-294.

Fenton, Carroll Laar, and Fenton, Mildred Adams. 1952. *Giants of Geology*. Garden City, NY: Doubleday and Co., Inc.

Switzer, George S. 1971. Questing for gems. *National Geographic* 140(Dec.): 834-863.

20-3

What's a Rockhound?

Segment Synopsis

Mineralogy is one of the most popular hobbies in our country. What better way to learn about the hobby and simple identification techniques than by talking to a rockhound. Jim Irvine became a rockhound when his eight-year-old son needed to make a rock collection. Since then the hobby has absorbed most of his spare time. Jim introduces the hobby and science in an informal conversation. After outlining his identification procedure, Jim demonstrates his method of cleaning specimens and the simple tests he uses for identifying minerals by luster, specific gravity, hardness, cleavage, and fracture. Students can follow the logical steps required for identification and gain an understanding of the unique and almost unlimited hobby of "rockhounding."

Concepts

- Many scientific pursuits can be converted into productive and enjoyable hobbies.
- Earth materials behave according to basic natural laws.
- The physical properties of earth materials are determined by the kind and arrangement of atoms comprising them.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain how simple tests can identify the basic crystal structure of a mineral
- demonstrate the sequence of simple tests and logic used to identify minerals
- explain the kinds of activities "rockhounds" carry out as a hobby.

Learning Activities

Have students read about "rockhounding" as a hobby and locate the nearest rock and mineral club.

Have students investigate common mineral tests such as luster, hardness, specific gravity, cleavage, and fracture. Also include one or two simple chemical tests.

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Have students conduct #2-3: "Investigating Rocks and Minerals" investigation from Miles F. Harris's, et al. Earth Science Curriculum Project textbook, INVESTIGATING THE EARTH (1973), published by Houghton Mifflin Company, Boston, Massachusetts.

Invite a local rockhound to demonstrate his hobby to your students.

Hold a student rock swap at your school and invite students from nearby schools to join you.

Have students write and produce their own mineral story using super 8mm film, videotape, or slides.

Media Resources

FILMS

MINERALS AND ROCKS. 16mm. 16 min. sd. color. Ency. Britannica Ed. Corp.

Note: See the U. S. Bureau of Mines film listings for films on various minerals and mineral resources of different states.

FILM LOOPS

INVESTIGATIONS IN SCIENCE: EARTH SCIENCE SERIES. 1 color film loop. Bailey-Film Associates, 1970.

MINERAL PROPERTIES PARTS 1 AND 2. 2 color film loops. Hubbard Scientific Co.

FILMSTRIPS

DISCOVERING ROCKS AND MINERALS. 4 filmstrips. 2 recordings. Coronet Films, 1970.

ROCKS AND MINERALS. 4 filmstrips. 2 cassettes. Learning Resources Corp., 1974.

SLIDES

MINERALS. 20 color slides. Ward's Natural Science Establishment, Inc.

ROCKS AND THEIR MINERALS. 20 slides. Society for Visual Education.

WHAT ON EARTH? SLIDE SET G/20/3.

STEREO STUDY BOOK

Tachter, David. STEREOGRAM BOOK OF ROCKS, MINERALS AND GEMS. Hubbard Scientific Co.

KITS

CLEAVAGE COLLECTION. set of specimens. Ward's Natural Science Establishment, Inc.

DENSITY KIT. set of shapes. Ward's Natural Science Establishment, Inc.

EARTH MATERIALS KIT. quantities of 25 specimens. Hubbard Scientific Co.

FRACTION COLLECTION. set of specimens. Ward's Natural Science Establishment, Inc.

LUSTER COLLECTION. set of specimens. Ward's Natural Science Establishment, Inc.

ROCK FORMING MINERALS. 100 specimens, each on a tray. Ward's Natural Science Establishment, Inc.

CHART

ROCK IDENTIFICATION KEY. Earth Science Materials.

Teacher References

Dietrich, R. V. 1969. *Mineral Tables: Hand-Specimen Properties of 1500 Minerals.* New York: McGraw-Hill Book Co.

Frondel, Clifford. 1962. *The System of Mineralogy of James Dwight Dana and Edward Salisbury Dana.* 3 vols. New York: John Wiley and Sons, Inc.

Pough, Frederick H. 1976. *A Field Guide to Rocks and Minerals.* 4th ed. Boston: Houghton Mifflin Co.

Tennissen, A. 1974. *Nature of Earth Materials.* New York: Prentice-Hall, Inc.

21

Our Dynamic Planet

The Rock Cycle
The Continents are Moving

Program Overview

This program begins a sequence which covers the major topics in physical geology. What has and is happening to the earth's crust has a profound effect on our lives. Long term changes have built mountains, plains, and plateaus; shorter term changes have resulted in canyons, deltas, and other surface features. Continuing processes also affect us as rivers change their course, volcanoes erupt, and earthquakes shake the crust. In this program, students are introduced to the comprehensive ideas that explain how the crust is changing. The first segment examines the rock cycle, illustrating each stage and its relation to the others. The second segment traces the development of the plate tectonics theory (continental drift) and demonstrates how that theory accounts for mountain building around the world.

Textbook References

- A SEARCH FOR UNDERSTANDING
    - Ch. 5-1: Crust, Mantle and Core, pp. 150-153
    - Ch. 6-4: The Restless Rocks, pp. 196-200
- MODERN EARTH SCIENCE
    - Ch. 10: Movements of the Earth's Crust, pp. 207-231
- PATTERNS IN OUR ENVIRONMENT
    - Ch. 5-14: Metamorphic Rocks--The Link in the Rock Cycle, pp. 125-126
    - Ch. 8-10: Floating Continents? pp. 237-238
    - Ch. 8-11: Drifting Continents and the Earth's Interior, pp. 238-239
    - Ch. 8-12: Active Belts in the Earth's Crust, pp. 240-242
- THE WORLD WE LIVE IN
    - Ch. 14: Mountains, Plateaus, and Plains, pp. 207-225
- EARTH SCIENCE: A LABORATORY APPROACH
    - Ch. 8-1: Mountains Form the Earth, p. 163
    - Ch. 8-3: Theories About Mountain Building, pp. 166-169
- EARTH SCIENCE: IIS
    - Idea 4-8: Even Rocks Are Recycled, pp. 157-160
    - Idea 6-2: Even the Earth Does Not Sit Still, pp. 207-210
- FOCUS ON EARTH SCIENCE
    - Ch. 17-1: Diastrophism, pp. 318-320
    - Ch. 17-2: Internal Forces, pp. 321-325
    - Ch. 17-3: Continental Drift Theory, pp. 326-336
    - Ch. 4-3: Rocks, pp. 84-91
- HOLT: EARTH SCIENCE
    - Ch. 1: Plate Tectonics, pp. 16-42
- INVESTIGATING THE EARTH
    - Ch. 11: Mountains From the Sea, pp. 233-258

- OUR ENVIRONMENT IN SPACE
  - Ch. 22: Bending and Breaking of the Earth's Crust, pp. 455-488
  - Ch. 23: Rifting of Ocean Basins and Continents, pp. 489-507
- PATHWAYS IN SCIENCE
  - No references

Student Readings

Anderson, Alan H., Jr. *The Drifting Continents.* New York: G. P. Putnam's Sons, 1971.

Calder, Nigel. *The Restless Earth.* New York: Viking Press, Inc., 1972.

Colbert, Edwin. *Wandering Lands and Animals.* New York: E. P. Dutton and Co., Inc., 1973.

Glen, William. *Continental Drift and Plate Tectonics.* New York: Charles E. Merrill Publishing Co., 1975.

Golden, Frederic. *The Moving Continents.* New York: Charles Scribner's Sons, 1972.

Hamilton, Andrew. "Glomar Challenger Drills Deep-Sea Peephole Into Earth's Past." *Popular Science*, May 1971, pp. 58-60.

Heirtzler, J. R., and R. D. Ballard. "Project Famous--Where the Earth Turns Inside Out." *National Geographic*, May 1975, pp. 586-597, 602-615.

Hyde, Margaret D. *The Earth In Action.* New York: McGraw-Hill Book Co., 1969.

Institute of Geological Sciences. *The Story of the Earth.* London: Her Majesty's Stationery Office, 1972.

Lauber, Patricia. *This Restless Earth.* New York: Random House, 1970.

________. *Earthquakes: New Scientific Ideas About How and Why the Earth Shakes.* New York: Random House, 1972.

Ley, Willy. *The Drifting Continents.* New York: David McKay Co., Inc., 1969.

Marvin, Ursula B. *Continental Drift: The Evolution of a Concept.* Washington, DC: Smithsonian Institution Press, 1973.

Speicher, John. "Plate Tectonics: A Startling New View of Our Turbulent Earth." *Popular Science*, June 1972, pp. 84-89.

Sullivan, Walter. *Continents in Motion.* New York: McGraw-Hill Book Co., 1974.

Tarling, Don, and Maureen Tarling. *Continental Drift: A Study of the Earth's Moving Surface.* Garden City, NY: Doubleday and Co., Inc., 1975.

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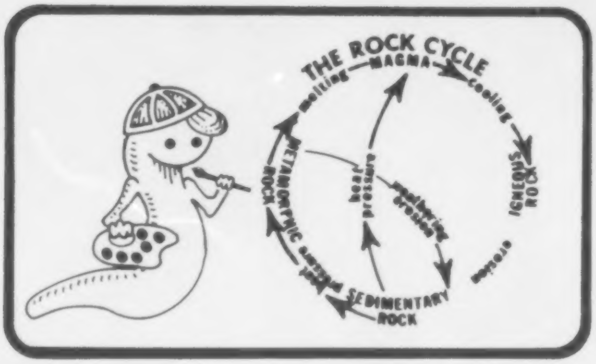


The Rock Cycle

Segment Synopsis

THE ROCK CYCLE introduces students to the major processes that change the surface of our planet. The segment begins with magma being thrown from the throat of a volcano. The cooling igneous rock is then followed as it hardens and is weathered with time into soil. The eroded soil is transported and deposited as a sediment, cemented to form sedimentary rock and still later subjected to the heat and pressure that results in metamorphism. The result is that in this short segment, students may follow earth materials through the entire rock cycle in a brief period of time. The segment's emphasis is on the entire process. It presents a model which can be used later to connect more detailed treatments of each phase of the cycle.

Concepts

- Natural forces acting today are the same as those which have been acting throughout the ages.
- Minerals may indicate environments. Depending on the conditions, the same chemical elements may combine to form minerals and rocks of varying composition and texture.
- The rocks on and in the crust change in response to changes in their environments.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain the theory of uniformitarianism as it relates to the rock cycle
- explain and diagram the relationship of different kinds of rock within the rock cycle and describe how the cycle responds to changing environments.

Learning Activities

Have students assemble examples of the major rock types and construct a display.

Students should be introduced to the following terms prior to viewing the segment: magma, igneous rock, weathering, erosion, sediment, sedimentary rock, metamorphic rock. However they should not be required to understand their meanings in detail as the terms will be emphasized in later segments.

Have students collect photographs of processes involved in the rock cycle and construct a bulletin board or display using the materials. If specimens are available they should be included. Students should stress modifications and changes in pathways that may occur in the cycle.

Media Resources

FILM

THE EARTH IN CHANGE: THE EARTH'S CRUST. 16mm. 16 min. sd. color. Ency. Britannica Ed. Corp.

FILM LOOP

ROCK CYCLE. 1 color film loop. Hubbard Scientific Co.

FILMSTRIPS

EARTH SCIENCE: THE ROCK CYCLE. 2 filmstrips, 1 disc recording. Society for Visual Education.

THE ROCK CYCLE. Solo Learn. 1 filmstrip. 1 cassette tape. Ward's Natural Science Establishment, Inc.

SLIDES

WHAT ON EARTH? SLIDE SET G/21/1.

TRANSPARENCIES

THE ROCK CYCLE. 1 color transparency. Hammond Inc.

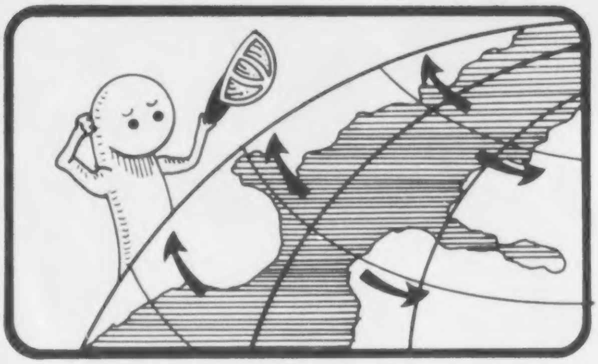
ROCK CYCLE. 1 color transparency. Hubbard Scientific Co.

MODEL

ROCK CYCLE MODEL. 24" x 18" model, 20 rock specimens. Hubbard Scientific Co.

Teacher Reference

Singh, Raman J., and Bushee, Jonathan. 1977. The rock cycle. *The Journal of Geological Education* 25 (Nov): 146-147.



The Continents are Moving

Segment Synopsis

THE CONTINENTS ARE MOVING is a straightforward explanation of the ideas underlying the theory of plate tectonics. The segment begins with a statement of the theory of uniformitarianism and the problems that developed as James Hall tried to explain rock sequences in the northern Appalachians. The idea is developed in historical perspective moving from the early theory of isostasy, to the scientific process of ocean floor mapping, then to the discovery of magnetic bands on either side of the Mid-Atlantic Ridge, and the revival of Alfred Welthers theory of "continental drift." Students see isostasy explained using models and get on board the GLOMAR CHALLENGER to view drilling procedures which verified oceanic crustal spreading. Extensive use of graphics allows students to see how crustal plates match, and trace rock units from one plate to another. They also see the plate tectonic theory supported through the evidence of heat flow, seismic patterns, and volcanic eruptions around the world. The segment introduces subduction zones and sliding plate contacts such as the San Andreas fault zone. It concludes with a computer animation of crustal plate movement over the preceding two hundred million years.

Concepts

- Natural forces acting today are the same as those which have been acting through the ages. None of the many theories that have been proposed to account for the earth's overall surface configuration is wholly satisfactory.
- The theory of isostasy proposes that the less dense crust is floating on a more dense mantle.
- The theory of plate tectonics proposes that the earth's overall surface arrangement is determined by activity in the mantle which causes crustal plates to move about on the planet's surface.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain the theory of uniformitarianism as it applies to plate tectonics
- explain the basic ideas involved in the theory of plate tectonics
- give examples of surface features that yield evidence of tectonal activity in the earth's crust.

Learning Activities

This segment may be used before studying folding, metamorphism, and other geologic concepts as an introduction to the underlying theoretical framework of geology or as a review and theoretical answer to evidence previously studied.

Students should be aquainted with the following terms prior to viewing the segment: continent (including continent names), crust, mantle, volcanic, seismic, uniformitarianism, isostasy.

Have students collect newspaper accounts of volcanic eruptions and earthquakes and plot them on world map which shows the physiographic configuration of the ocean floor.

Have students prepare models, displays or posters illustrating the structure of subduction and rift zones.

Have students prepare a series of posters all using the same format, to show the position of the continents at various times in the geologic past. One possible source of information is the article "Continental Drift Reconstruction and Animation" by C. R. Scotese and D. W. Baker in the JOURNAL OF GEOLOGICAL EDUCATION, Vol. 23, No. 5 (1975), pp. 167-171.

Have students try the activities described in the following articles:

1. Beck, Myrl, et al. 1977. Which way is north? THE JOURNAL OF GEOLOGICAL EDUCATION 25 (Nov.): 141-143.
2. Wielert, Jan S. 1977. A teaching strategy employing polar wandering data. JOURNAL OF GEOLOGICAL EDUCATION 25 (Sept.): 106-107.

Media Resources

FILMS

CONTINENTS ADRIFT. 16mm. 15 min. sd. color. American Educational Films, 1971.

DEEP SEA DRILLING PROJECT. 16mm. 27 1/2 min. sd. color. Association--Sterling Films. (a National Science Foundation Film)

NOT SO SOLID EARTH. 16mm. 25 min. sd. color. Time-Life Films, 1971.

THAT VERY SPECIAL SHIP. 16mm. 27 min. sd. color. RHR Filmedia Inc., 1974. (a National Science Foundation Film)

THE RESTLESS EARTH: PLATE TECTONICS THEORY. 16mm. 58 min. sd. color. Indiana Univ. Film Library, 1972.

FILMSTRIPS

CONTINENTAL DRIFT I: A THEORY IS BORN. Solo Learn. 1 filmstrip, 1 cassette tape. Ward's Natural Science Establishment, Inc.

CONTINENTAL DRIFT II: SEAFLOOR SPREADING. Solo Learn. 1 filmstrip, 1 cassette tape. Ward's Natural Science Establishment, Inc.

SLIDES

WHAT ON EARTH? SLIDE SET G/21/2.

MAPS

PHYSIOGRAPHIC MAPS SERIES. National Geographic Society.

GEOLOGICAL MAP SERIES. Geological Society of America.

Teacher References

Anderson, Susan H. 1975. Man's first look at the mid-ocean ridge. *NOAA* Jan: 12-19.

Bisque, Ramon E. 1970. A controversy is born. *The Science Teacher* 37 (April): 35-41.

Cloud, Preston, ed. 1970. *Adventures in Earth History: Original Selections From Steno to Present.* San Francisco: W. H. Freeman and Co.

Davies, T. A. 1976. Five hundred holes and seventy-three holes in the bottom of the sea--some results from seven years of deep-sea drilling. *Journal of Geological Education* 24: 143-154.

Kauffman, Erle G. 1976. Plate tectonics--major force in evolution. *The Science Teacher* March: 13-17.

Korporaal, Arie, et al. 1978. How fast is the ocean floor moving? *Journal of Geological Education* 26 (May): 104-107.

Scientific American Editors. 1976. *Continents Adrift and Continents Aground.* Readings from *Scientific American.* San Francisco: W. H. Freeman and Co.

Seyfert, Carl K., and Sirkin, Leslie A. 1973. *Earth History and Plate Tectonics: An Introduction to Historical Geology.* New York: Harper and Row.

Wegener, Alfred. 1966. *The Origin of Continents and Oceans.* New York: Dover Publications, Inc.

Wyllie, Peter J. 1976. *The Way the Earth Works: An Introduction to the New Global Geology and Its Revolutionary Development.* New York: John Wiley and Sons, Inc.

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22

When the Earth Moves

Folds, Faults, and Mountains
When the Earth Shakes
Mountains are the
Wild Places of the Earth

Program Overview

These next programs, following the introduction of the plate tectonics theory, look at the most discernible features involved in the structure of the earth. The folds, faults, and earthquakes that result from stress and strain on the crust are all a part of the process of mountain building. This program opens with a photographic introduction to folds and faults, proceeds to a discussion of earthquakes as the outward sign of tectonic activity and concludes with an excursion into high mountain country. The first segment dealing with folds and faults is purely instructional; the second attempts to recreate the feeling of an actual earthquake; and the final segment is an attempt to help students understand the environment in high mountain areas where few people are privileged to live or visit.

Textbook References

- A SEARCH FOR UNDERSTANDING
    - Ch. 5-2: Forces Within the Earth, pp. 154-159
    - Ch. 5-3: Rocks Change Their Shapes, pp. 159-165
    - Ch. 5-4: Earthquakes, pp. 165-170
    - Ch. 2-2: The Appalachian Highlands, pp. 55-59
    - Ch. 2-4: The Western Highlands, pp. 66-71
    - Ch. 2-5: The Pacific Coast, pp. 71-75
    - Ch. 7-4: Mountains, pp. 223-231
- MODERN EARTH SCIENCE
    - Ch. 10: Movements of the Earth's Crust, pp. 207-231
- PATTERNS IN OUR ENVIRONMENT
    - Ch. 8-12: Active Belts in the Earth's Crust, pp. 240-242
    - Ch. 8-13: Another Interpretation of the Earthquake Belt Pattern, pp. 243-244
    - Ch. 8-14: Rouse Belts, p. 245
- THE WORLD WE LIVE IN
    - Ch. 12: Diastrophism, pp. 182-191
    - Ch. 15: Earthquakes, pp. 226-237
    - Ch. 14: Mountains, Plains, and Plateaus, pp. 207-225
- EARTH SCIENCE: A LABORATORY APPROACH
    - Ch. 8-4: A Look at the Appalachian Mountains, pp. 170-171
    - Ch. 8-5: The Rocky Mountains--A Spine for the Continent, p. 172
    - Ch. 8-6: Mountain Building By Faulting, pp. 173-174
- EARTH SCIENCE: IIS
    - Idea 8-3: Do Not Bend or Spindle, pp. 287-292.
    - Idea 8-4: It's Not My Fault, pp. 293-298

- FOCUS ON EARTH SCIENCE
  - Ch. 17: Crustal Movement, pp. 318-326, 335-352
  - Ch. 18: Earthquakes, pp. 353-373
- HOLT: EARTH SCIENCE
  - Ch. 1: Plate Tectonics, pp. 16-42
  - Ch. 2: Bending the Crust, pp. 64-96
- INVESTIGATING THE EARTH
  - Ch. 13: Studying the Interior of the Earth, pp. 280-288
  - Ch. 11: Mountains from the Sea, pp. 253-258
- OUR ENVIRONMENT IN SPACE
  - Ch. 22: Bending and Breaking of the Earth's Crust, pp. 465-488
- PATHWAYS IN SCIENCE
  - II Ch. 1: Action in the Earth, pp. 73-77
  - II Ch. 3: Mountains Rise, pp. 83-86

Student Readings

Atwood, W. W. *The Rocky Mountains.* New York: Vanguard Press, 1945.

Brooks, Maurice. *Appalachians.* Boston: Houghton Mifflin Co., 1965.

Canby, Thomas Y. "California's San Andreas Fault." *National Geographic,* Jan. 1973, pp. 38-52.

Incopi, Robert, ed. *Earthquake Country: California.* rev. ed. Menlo Park, CA: Lane Publishing Co., 1971.

Institute of Geological Sciences. *The Story of the Earth.* London: Her Majesty's Stationery Office, 1972.

Lauber, Patricia. *This Restless Earth.* New York: Random House, 1970.

Leet, L. D., and Florence Lest. *Earthquake: Discoveries in Seismology.* New York: Dell Publishing Co., Inc., 1964.

Levenson, David. *A Sense of the Earth.* Garden City, NY: Natural History Press, 1971.

Love, J. D., and J. C. Reed, Jr., *Creation of the Teton Landscape: The Geologic Story of Grand Teton National Park.* Moose, WY: Grand Teton Natural History Association, 1968.

McKee, Bates. *Cascadia: The Geologic Evolution of the Pacific Northwest.* New York: McGraw-Hill Book Co., 1972.

Pakiser, L. C., *Earthquakes.* Washington, DC: U. S. Geological Survey, 1976. (pamphlet)

U. S. Geological Survey. *Active Faults of California.* Washington, DC: U. S. Government Printing Office, 1976. (pamphlet)

Zim, Herbert S. *Rocky Mountains.* New York: Western Publishing Co., Inc., 1964.

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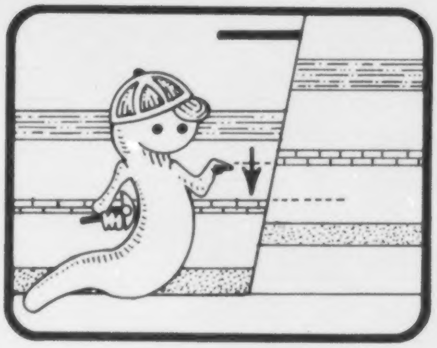


Folds, Faults, and Mountains

Segment Synopsis

FOLDS, FAULTS, AND MOUNTAINS introduces students to the major types of deformational forces and the landforms that may result when they are present. The program begins by describing anticlines and synclines using examples from the open folds of the Ridge and Valley Province in Virginia. Examples are shown of small drag folds, chevron folds, flow folds, and megascopic folds in the Canadian Rockies. The relationship of landforms to their underlying geologic structure is stressed through a brief look at the ridges produced by erosion of the Sinking Creek anticline in Virginia, and mountain valleys, like the Massanutten Mountain in Virginia and Mount Monadnock in New Hampshire, both formed by erosion of a recumbent anticline. Next, fractions are presented; normal, reverse and strike slip faults are defined and illustrated by field examples in Virginia, Wyoming and California. The segment concludes with examples of faults that formed large features such as the Grand Tetons and Sierra Nevada Mountains.

Concepts

- The natural forces acting today are the same as those which have been acting through the ages.
- Rocks respond to deformational forces which raise mountains by folding and faulting.
- Mountains are formed when crustal rocks respond to forces acting within the crust.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- demonstrate an understanding of the theory of uniformitarianism as it relates to folding and faulting
- explain and illustrate the basic types of folds, joints, and faults
- explain how folding and faulting result in the raising of certain types of mountains.

Learning Activities

Prior to viewing this segment students should be introduced to the following terms: folds, anticline, syncline, plunging fold, joint, joint set, fault, normal fault, reverse fault, strike-slip fault.

Have students collect pictures of mountains and attempt to classify them into folded, faulted, and volcanic groups.

Have students try to locate folded, faulted, or jointed rocks in the school area and describe their features.

Have students construct models of an anticline, syncline, normal fault, reverse fault, and strike slip fault.

Have students construct bulletin board displays explaining the various parts of the principle types of folds and faults.

Have students prepare reports and displays describing topography, physiography, and geology of areas within the United States that have been formed by folding or faulting. Some possible examples are listed below:

Features	Location
Open folds	Ridge and Valley Province of Pennsylvania, Virginia, Tennessee, and Kentucky
Open folds	Sheep Mountain just west of the Bighorn Mountains in Wyoming area
Open folds	Waldron, Arkansas in the Wichita National Forest
Normal or Gravity Faults	Triassic Basins in North and South Carolina, Virginia, Maryland, New Jersey, and Connecticut Piedmont regions. Basin and range province in Nevada.
Reverse Faults	Eastern front of the Southern Sierra Nevada Mountains in California; Grand Tetons in Wyoming including the area known as Jackson Hole. Front Range of the Rocky Mountains in the area from Colorado Springs to Denver and Boulder, Colorado.
Thrust Faults	Pine Mountains in Eastern Tennessee and Kentucky. Chief Mountain in Montana.
Strike Slip Faults	San Andreas, Garlock and other related faults stretch the length of the California coast.

Media Resources

FILMS

HOW SOLID IS ROCK? 16mm. 22 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

THE SAN ANDREAS FAULT. 16mm. 21 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

WHY DO WE STILL HAVE MOUNTAINS? 16mm. 21 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

FILM LOOPS

FAULT BLOCK MOUNTAINS, PARTS 1 AND 2. 2 color film loops. Ward's Natural Science Establishment, Inc.

FOLDED MOUNTAINS, PARTS 1 AND 2. 2 color film loops. Ward's Natural Science Establishment, Inc.

FILMSTRIPS

GEOMORPHOLOGY. 6 color filmstrips. Ward's Natural Science Establishment, Inc.

SLIDES

LANDFORMS I. 20 color slides. Ward's Natural Science Establishment, Inc.

MOUNTAIN BUILDING. 20 color slides. Ward's Natural Science Establishment, Inc.

WHAT ON EARTH? SLIDE SET G/22/1.

TRANSPARENCIES

COASTAL PLAINS, FOLDS AND VOLCANOES. 17 color transparencies. Ward's Natural Science Establishment, Inc.

Teacher References

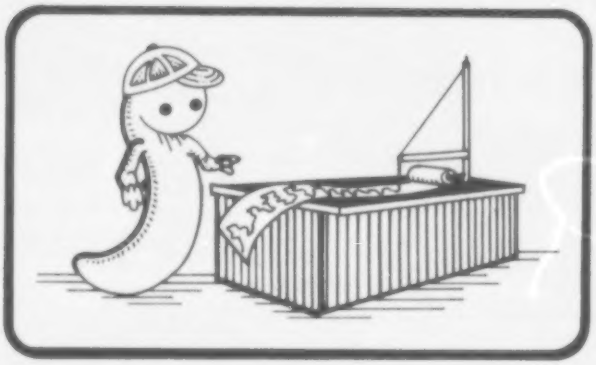
Anderson, Don L. 1971. The San Andreas Fault. *Scientific American* 225 (Nov): 12, 52-66.

Thomas Y. 1973. California's San Andreas Fault. *National Geographic* 143 (Jan): 38-52.

Spencer, Edgar W. 1977. *Introduction to the Structure of the Earth.* 2nd ed. New York: McGraw-Hill Book Co.

22-2

When the Earth Shakes



Segment Synopsis

While the discussion of faults in Segment One stressed their structure, this segment, WHEN THE EARTH SHAKES, deals with the result of movement along such crustal breaks. The segment opens with a recreation of the 1959 earthquake in Montana's Hebgen Valley. It shows the geologic structure responsible for the quake and the surface features that resulted from the quake. Then emphasis shifts to the study of seismic waves. During a visit to the seismic station at the University of North Carolina in Chapel Hill, students see how a seismograph works, visit a working seismic vault, and learn about the types of waves measured. Students watch seismologists interpret seismograms and locate the epicenter of an earthquake. The segment concludes with a brief look at the "ring-of-fire" earthquake belts, the Alaskan earthquake of 1964, and suggests that future research may make it possible to predict quakes and thus reduce damage and loss of life.

Concepts

- Natural forces acting today are the same as those which have been acting through the ages.
- Rocks respond to stress within the earth by breaking along plains of weakness. The motion generates seismic waves which travel through the crust.
- Seismic waves provide evidence about the general structure and composition of the earth's interior.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- relate the theory of uniformitarianism to the phenomena associated with earthquakes
- explain how earthquakes are created and describe the types of seismic waves generated by an earthquake
- describe ways in which seismic waves are measured and related to damage.

Learning Activities

Prior to viewing this segment, students should be introduced to the following terms: seismic wave; seismograph; seismogram; P, S, and L waves; fault.

For a long-term project, have students record and plot earthquakes reported by the news media.

Have students read about famous earthquakes in back issues of newspapers and journals such as the NATIONAL GEOGRAPHIC.

Have students prepare reports or bulletin board displays describing famous earthquakes such as the 1964 Alaskan Quake or the 1974 California Quake.

Have students construct both vertical and horizontal working models of seismographs and use them as the center of displays which explain how the instruments detect seismic waves.

Have students conduct the #11-5 "Investigating Earthquakes" investigation from Miles F. Harris's, et al. Earth Science Curriculum Project textbook INVESTIGATING THE EARTH (1973), published by Houghton Mifflin, Boston, Massachusetts.

Media Resources

FILMS

ALASKA EARTHQUAKE, 1964. 16mm. 22 min. sd. color. U. S. Geological Survey, 1966.

EARTHQUAKE! 16mm. 28 1/2 min. sd. color. National Audiovisual Center.

EARTHQUAKE BELOW. 16mm. 14 min. sd. color. National Aeronautics and Space Administration, 1975.

EARTHQUAKES: LESSON OF A DISASTER. 16mm. 13 min. sd. color. Ency. Britannica Ed. Corp.

RESPONSE TO DISASTER. 16mm. 20 min. sd. color. U. S. Army Engineer Division South Atlantic, 1964.

THE RESTLESS EARTH: EARTHQUAKES. 16mm. 26 min. sd. color. Indiana Univ. Audiovisual Center.

TSUNAMI. 16mm. 28 min. sd. color. National Oceanic and Atmospheric Administration.

WARNING EARTHQUAKE! 16mm. 24 min. sd. color. Ency. Britannica Ed. Corp. (from the Wide World of Adventure program)

FILMSTRIP

EARTHQUAKES. Solo Learn. 1 filmstrip, 1 cassette tape. Ward's Natural Science Establishment, Inc.

SLIDES

WHAT ON EARTH? SLIDE SET G/22/2.

Teacher References

Adams, W. M. 1964. *Earthquakes: An Introduction to Observational Seismology*. Boston: D. C. Health and Co., Inc.

Carter, Dean S. 1956. *The Seismograph and the Seismograph Station*. Washington, DC: U. S. Coast and Geodetic Survey. (pamphlet)

Eckel, E. B. 1970. *The Alaska Earthquake, March 20, 1964--Lessons and Conclusions* U. S. Geological Survey Professional Paper 546. Washington, DC: U. S. Government Printing Office.

Lehman, James D. 1977. Practical seismograph tracks tremors. *The Science Teacher* 44 (Nov.): 43-45.

National Oceanic and Atmospheric Administration. 1973. *Earthquake History of the United States.* rev. ed. Washington, DC: U. S. Government Printing Office.

Press, Frank. 1975. Earthquake prediction. *Scientific American* 232 (May): 14-23.

Richter, C. F. 1958. *Elementary Seismology.* San Francisco: W. H. Freeman and Co.

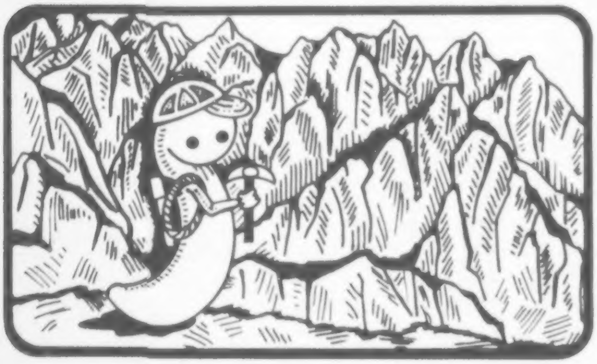
Scholz, C. H. 1974. Toward infallible earthquake prediction. *Natural History* May: 54-59.

U. S. Geologic Survey. 1964. *The Hebgen Lake, Montana Earthquake of August 17, 1959.* U. S. Geological Survey Professional Paper 435. Washington, DC: U. S. Government Printing Office.

———. 1974. *Seismicity Map of the World.* Arlington, VA: U. S. Geological Survey Distribution Branch. (map)

———. 1976. *Earthquake Prediction--Opportunity to Avert Disaster.* U. S. Geological Survey Circular 729. Washington, DC: U. S. Government Printing Office. (pamphlet)

U. S. Geological Survey and Office of Emergency Preparedness. 1969. *Safety and Survival in an Earthquake.* Washington, DC: U. S. Government Printing Office. (pamphlet)



Mountains are the Wild Places of the Earth

Segment Synopsis

Mountains, rugged and forbidding, are very special places. This segment takes students to the Rockies, to the very roof of our continent to experience the special environment that exists on top of mountains. Students watch as seasons pass, experience the beauty of nature and gain new insights into the forces that, in time, will reduce the towering peaks to rolling hills and valleys. The stark quiet of high country, the roar of winter wind and falling water, the peace of a snowbound forest, and the beauty of towering peaks and shear cliffs, combine to envelope the students in the magic of high mountains.

Concepts

- Natural forces acting today are the same as those which have been acting through the ages.
- The landscape may be considered the product of internal and external processes working on rocks exposed at the interface.
- The environment of an area is the result of its geologic history, present climate, and man's activity.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain mountains as a product of uplift and erosion
- describe the environment of high mountains
- explain the present stage of a mountainous area as one stage in an overall cycle lasting millions of years.

Learning Activities

You may not wish to plan many previewing activities. Instead concentrate on a follow-up discussion that emphasizes the profound emotional impact of a high mountain experience.

Have students read the commentaries of mountaineers and explorers.

Have students collect and display photographs that reveal the environment of high mountain country.

Invite students or parents who have visited or worked in high mountain country to visit the class and describe their experiences.

In cooperation with their English teacher, have students write papers or poems about the earth's special places.

Have students draw or paint pictures portraying the many moods of high mountain country.

Media Resources

FILMS

HIGH COUNTRY AWAKES. 16mm. 14 min. sd. color. Colorado State Division of Commerce and Development.

HIGH IN THE HIMALAYAS. 16mm. 27 min. sd. color. Association - Sterling Films.

MOUNTAINS OF THE U.S.A. 16mm. 15 min. sd. color. Macmillan Films. (a title in the Our Land, Our People, U.S.A series)

SOLO. 16mm. 15 min. sd. color. Pyramid Films.

TETON TRAILS. 16mm. 27 min. sd. color. Wyoming Travel Commission.

WHITEFACE OF YELLOWSTONE. 16mm. 27 min. sd. color. Montana Highway Commission.

Teacher References

Arden, Harvey. 1973. John Muir's Wild America. *National Geographic* 143 (April): 433-461.

Craighead, Karen, and Craighead, Derek. 1972. A walk through the wilderness. *National Geographic* 141 (May): 579-603.

Ellis, William S. 1972. The pitfalls of success. *National Geographic* 141 (May): 616-631.

Fenton, Carroll L., and Fenton, Mildred. 1942. *Mountains.* Garden City, NJ: Doubleday and Co., Inc.

Spencer, Edgar W. 1977. *Introduction to the Structure of the Earth.* 2nd ed. New York: McGraw-Hill Book Co.

23

Changing Rock

Molten Rock
Heat, Pressure, Rock

Program Overview

Igneous and metamorphic rocks are two of the three major rock types found on our planet. They are related to one another because both rocks form under conditions of elevated temperature and pressure. Segment One, MOLTEN ROCKS, and Segment Two, HEAT, PRESSURE, ROCK, explore the processes that create the rocks and the landforms that result. The program looks at the information about the earth's history that may be gained through the study of igneous and metamorphic rocks.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 3-5: Some Ways of Identifying Common Rocks, pp. 106-112
  - Ch. 5-5: Volcanoes, pp. 170-176
  - Ch. 5-6: Hot Springs, Fumaroles, and Geysers, pp. 176-180
- MODERN EARTH SCIENCE
  - Ch. 8: Materials of the Earth's Crust, pp. 153-181
  - Ch. 9: The Restless Earth, pp. 182-206
- PATTERNS IN OUR ENVIRONMENT
  - Ch. 5-8: Granite, p. 119
  - Ch. 5-9: Basalt--The Igneous Floor of the Oceans, p. 120
  - Ch. 5-14: Metamorphic Rocks--The Link in the Rock Cycle, pp. 125-126
- THE WORLD WE LIVE IN
  - Ch. 5: Origin of the Rocks, pp. 47-71.
  - Ch. 13: Vulcanism, pp. 192-206
- EARTH SCIENCE: A LABORATORY APPROACH
  - Ch. 8-2: Sorting of Earth Materials During Cooling and Hardening, pp. 164-165
  - Ch. 8-7: Rocks of Molten Origin, p. 175
  - Ch. 8-8: Igneous Rocks--Another Family of Earth's Crustal Materials, p. 176
  - Ch. 8-9: Intrusions of Magma, p. 177
  - Ch. 8-11: Rocks Altered By Intense Heat and Pressure, p. 181
- EARTH SCIENCE: IIS
  - Idea 4-2: Even Rocks Have Parents, pp. 125-132
  - Idea 4-3: How Many Quartz in a Magma?, pp. 133-136
  - Idea 4-6: Even Rocks Have to Change, pp. 147-152
  - Idea 4-7: It Pays to be Gneiss, pp. 153-156
  - Idea 8-5: The Mountain That Roars, pp. 299-304
  - Idea 8-6: Mountains that Tell Tales, pp. 305-310
- FOCUS ON EARTH SCIENCE
  - Ch. 5: Igneous Rocks, pp. 92-107
  - Ch. 7: Metamorphic Rocks, pp. 127-141

- HOLT: EARTH SCIENCE
    - Ch. 1: Plate Tectonics, pp. 16-42
    - Ch. 6: Rocks, pp. 153-173
- INVESTIGATING THE EARTH
    - Ch. 12: Rocks Within Mountains, pp. 259-278
- OUR ENVIRONMENT IN SPACE
    - Ch. 21: Rise of Molten Rock in the Earth's Crust, pp. 444-463
    - Extending Unit 5: Metamorphic Rocks, pp. 524-527
- PATHWAYS IN SCIENCE
    - II Ch. 2: The Exploding Mountains, pp. 78-82
    - II Ch. 3: Mountains Rise, pp. 83-87
    - I Ch. 3: Rocks From Fire, pp. 15-19

Student Readings

Briggs, Lymen J. "When Mt. Mazuma Lost Its Top." *National Geographic*, July 1962, pp. 128-133

Bullard, F. M. *Volcanoes of the Earth.* rev. ed. Austin: Univ. of Texas Press, 1976.

Fenton, Carroll Lane, and Mildred Adams Fenton. *The Rock Book.* New York: Doubleday and Co., Inc., 1970.

Keeter, William R. *The Geologic Story of Yellowstone National Park.* Geological Survey Bulletin 1347. Washington, DC: U. S. Government Printing Office, 1971.

Institute of Geological Sciences. *Volcanoes.* London: Her Majesty's Stationery Office, 1974.

Scofield, John. "A New Volcano Bursts From the Atlantic." *National Geographic*, June 1958, pp. 735-757.

U. S. Geological Survey. *Geysers.* Washington, DC: U. S. Government Printing Office, 1975. (pamphlet)

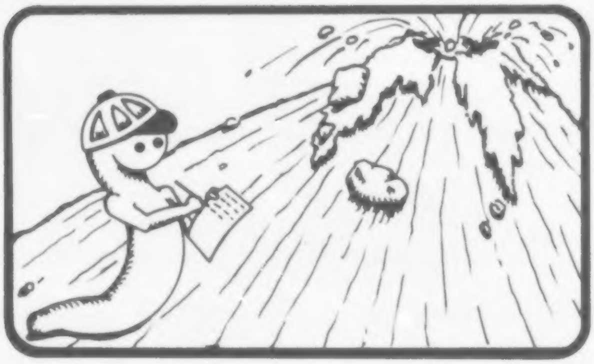
________. *Natural Stream for Power.* Washington, DC: U. S. Government Printing Office, 1975.

________. *Volcanoes of the United States.* Washington, DC: U. S. Government Printing Office, 1975. (pamphlet)

________. *Volcanoes.* Washington, DC: U. S. Government Printing Office, 1976. (pamphlet)

________. *Man Against Volcano: The Eruption of Heimaney, Westmann Islands.* Washington, DC: U. S. Government Printing Office, 1977. (pamphlet)

Zahl, Paul A. "Volcanic Fires of the 50th State: Hawaii National Park." *National Geographic*, June 1959, pp. 793-823.



23-1

Molten Rock

Segment Synopsis

MOLTEN ROCKS is a walking tour of the strange world of igneous rocks. The tour begins on the lava flows at Craters of the Moon National Monument, Idaho, where the principle theories dealing with the creation of magma are discussed and the differences between intrusive and extrusive rocks are clarified. Students see intrusive features such as batholiths, lacoliths, dikes, sills, and volcanic rocks. Various types of erosion explain the extrusive features of composite coves, cinder coves, and shield coves. Examples are shown of AA and Pahoehoe lava, lava tubes, and pillow lavas. The segment concludes with a look at the geysers, hot springs, mudpots, and fumeroles that result when ground water comes in contact with magma or cooling lava.

Concepts

- Natural forces acting today are the same as those which have been acting through the ages.
- Minerals may indicate environment. Depending on the conditions, the same chemical elements may combine to form minerals and rocks of varying composition and texture.
- Igneous rocks form from magma which originates either from melting rocks in the lower crust and upper mantle or from local melting at the roots of mountain ranges.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain how igneous rocks and landforms relate to the theory of uniformitarianism
- explain the formation of magma
- explain and diagram the differences between intrusive and extrusive igneous rocks
- explain and illustrate the more common intrusive and extrusive igneous landforms.

Learning Activities

Prior to viewing the segment, students should be acquainted with the following terms: magma, lava, igneous, intrusive, extrusive.

Have students collect pictures of volcanoes and other igneous features for use on a bulletin board. Students might wish to locate reports of eyewitness descriptions of eruptions and then build a display around the accounts.

Have students collect the following investigations from Miles F. Harris's, et al. Earth Science Curriculum Project textbook, INVESTIGATING THE EARTH (1973), published by Houghton Mifflin, Boston, Massachusetts:

12-2 Using a Geologic Map to Study Rocks, pp. 260-263

12-4 Investigating Plutonic Rocks, pp. 264-265

12-10 Investigating Volcanic Rocks, pp. 274-275

Media Resources

FILMS

CASE HISTORY OF A VOLCANO. 16mm. 30 min. sd. color. Indiana Univ. Audiovisual Center, 1966.

CRATERS OF THE MOON. 16mm. 12 min. sd. color. Idaho Dept. of Commerce and Development.

ECOLOGY OF A HOT SPRING: LIFE AT HIGH TEMPERATURES. 16mm. 15 min. sd. color. Ency. Britannica Ed. Corp.

ERUPTION OF KILAUEA, 1959-60. 16mm. 27 1/2 min. sd. color. U. S. Geological Survey, 1961.

FIRE UNDER THE SEA. 16mm. 20 min. sd. color. Moonlight Productions, 1974.

HEARTBEAT OF A VOLCANO. 16mm. 21 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

ERUPTION OF KILAUEA VOLCANO, HAWAIIAN ISLANDS, 1955. 16mm. 11 min. sd. color. U. S. Geological Survey, 1958.

ROCKS THAT ORIGINATE UNDERGROUND. 16mm. 23 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

SEASON OF FIRE. 16mm. 15 min. sd. color. Macmillan Films.

SURTSEY. 16mm. 26 min. sd. color. North Shore News.

TO YELLOWSTONE. 16mm. 18 min. sd. color. Wyoming Travel Commission.

VOLCANO: THE BIRTH OF A MOUNTAIN. 16mm. 24 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

WINTER GEYSER. 16mm. 7 min. sd. color. Pyramid Films.

FILM LOOPS

VOLCANOES PARTS 1 AND 2. 2 color film loops. Ward's Natural Science Establishment, Inc.

FILMSTRIPS

MATERIALS OF THE EARTH'S CRUST. 6 color filmstrips. Ward's Natural Science Establishment, Inc.

SLIDES

VOLCANO FEATURES. 20 color slides. Ward's Natural Science Establishment, Inc.

WHAT ON EARTH? SLIDE SET G/23/1.

TRANSPARENCIES

GEOLOGY VIEW AIDS. 6 color transparencies. Ward's Natural Science Establishment, Inc.

POSTERS

THE ATLAS OF VOLCANIC PHENOMENA. Twenty 16" x 20" posters. U. S. Geological Survey, 1971.

Teacher References

Bullard, Fred M. 1976. *Volcanoes of the Earth.* rev. ed. Austin: Univ. of Texas Press.

Cotton, C. A. 1969. *Volcanoes as Landscape Forms.* 2nd ed. New York: Hafner Press.

Crandell, D. R. 1960. *The Geologic Story of Mount Ranier.* U. S. Geological Survey Bulletin 1292. Washington, DC: U. S. Government Printing Office.

Deheshott, Gordon B. 1976. *Volcanoes and Earthquakes: Geologic Violence.* New York: McGraw-Hill Book Co.

Dietrich, R. V. 1974. Migmatites: a resume. *Journal of Geological Education* Sept: 144-156.

Fosher, W. P., and Gonzales, J. 1956. *Birth and Development of Paricutin Volcano, Mexico.* U. S. Geological Survey Bulletin 965-D. Washington, DC: U. S. Government Printing Office.

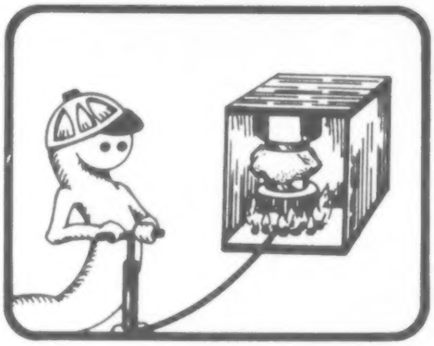
Hall, Alice J. 1971. The climb up Cone Crater. *National Geographic* 140 (July): 136-148.

Macdonald, Gordon A. 1972. *Volcanoes.* Englewood Cliffs, NJ: Prentice-Hall Inc.

Williams, Howel. 1941. *Crater Lake: The Story of Its Origin.* Berkley, CA: Univ. of California Press.

23-2

Heat, Pressure, Rock



Segment Synopsis

HEAT, PRESSURE, ROCK is the next logical step in the instructional sequence begun in Segment One. Students are introduced to the idea that although metamorphic processes take place deep within the earth, they can read the evidence of earlier metamorphic events by studying surface rocks exposed by erosion. Metamorphism is defined and the process illustrated using three common rock sequences: sandstone to quartzite, limestone to marble, and shale to slate. Two major types of metamorphism are considered: contact and regional metamorphism. Contact metamorphic changes are shown at the base of a lava flow and along the borders of a dike in the Triassic rocks of Durham, N. C. Then students take a field trip with Dr. Bill Spence to study the regional metamorphism caused by the intrusion of a large magma body in the North Carolina Piedmont. The trip begins almost fifty kilometers from the igneous body in low grade shales and moves toward the source of heat and pressure. Along the way he stops to study slates, phyllites, schists, gneisses, and migmatites. The trip concludes in a quarry at the edge of the igneous rocks where fragments of metamorphosed rock can be seen embedded in the ancient magma body. Throughout the segment, the effects of heat and pressure on rocks of different compositions are stressed.

Concepts

- Natural forces acting today are the same as those which have been acting through the ages.
- Minerals may indicate environment. Depending on the conditions, the same chemical elements may combine to form minerals and rocks of varying composition and texture.
- The rocks in and on the earth's crust change in response to fluctuations in their environment. Metamorphic rocks are produced from pre-existing solid rocks which are transformed by elevated temperatures and pressures.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- relate the process of metamorphism to the theory of uniformitarianism
- explain the process of metamorphism and give examples of metamorphic products and their parent rocks.

Learning Activities

Prior to viewing this segment, students should be introduced to the general idea that rocks may be changed by heat and pressure. Students may already know some possible sources of heat and pressure from earlier lessons on tectonics (See Segments 21-2 and 22-1).

Have students conduct #12-7 "Investigating Metamorphic Rocks" investigation from Miles F. Harris's, et al. Earth Science Curriculum Project textbook INVESTIGATING THE EARTH (1973), published by Houghton Mifflin, Boston, Massachusetts.

Media Resources

FILM

ROCKS THAT ORIGINATE UNDERGROUND. 16mm. 23 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Project)

FILMSTRIPS

METAMORPHIC ROCKS. Solo Learn. 1 filmstrip, 1 cassette tape. Ward's Natural Science Establishment, Inc.

MATERIALS OF THE EARTH'S CRUST. 6 color filmstrips. Ward's Natural Science Establishment.

SLIDES

ROCKS. 20 color slides. Ward's Natural Science Establishment.

WHAT ON EARTH? SLIDE SET G/23/2.

Teacher Reference

Pirsson, Louis V., and Knopf, Adolph. 1953. *Rocks and Rock Minerals*. New York: John Wiley and Sons, Inc.

24

Mapping the Earth's Resources

Mapping the Earth's Resources
The Problem of Mineral Resources

Program Overview

The most basic method for locating mineral resources and unraveling the earth's structure is geologic mapping. The first segment of this program allows students to follow the scientific method and thought processes of a group of geologists working on a geologic map. The second segment introduces students to the problem of mineral resource depletion and how it affects their everyday existence. Recycling is suggested as a possible solution.

Textbook References

- A SEARCH FOR UNDERSTANDING
    - Ch. 4: The Economic Importance of the Earth's Crust, pp. 114-144.
- MODERN EARTH SCIENCE
    - No references
- PATTERNS IN OUR ENVIRONMENT
    - Ch. 5-18: The Rocks in Your Area, p. 130
    - Ch. 5-19: Liquid Earth Materials, p. 131
    - Ch. 5-20: Gaseous Earth Materials, pp. 131-133.
    - Ch. 5-24: Junk and Garbage, pp. 138-139
    - Ch. 5-25: Invisible Wastes, pp. 140-141
- THE WORLD WE LIVE IN
    - Ch. 4: Ores and Their Origin, pp. 36-46
- EARTH SCIENCE: A LABORATORY APPROACH
    - No references
- EARTH SCIENCE: IIS
    - Idea 4-7: It Pays to be Gneiss, pp. 153-156.
    - Idea 4-8: Even Rocks are Re-Cycled, pp. 157-160
- FOCUS ON EARTH SCIENCE
    - Ch. 8: Products of the Lithosphere, pp. 142-159.
- HOLT: EARTH SCIENCE
    - Ch. 8: People, Resources, and Energy, pp. 202-242
- INVESTIGATING THE EARTH
    - Ch. 12-2: Using a Geologic Map to Study Rocks, pp. 260-261
- OUR ENVIRONMENT IN SPACE
    - Ch. 21: Rise of Molten Rock in the Earth's Crust, pp. 459-461
- PATHWAYS IN SCIENCE
    - I Ch. 8: Rocks and Metals for Building, pp. 41-45
    - I Ch. 9: Minerals for Work and Minerals for Beauty, pp. 46-50.

I Ch. 10: Artificial Building Materials, pp. 51-54
I Ch. 11: Pottery, China and Glass, pp. 55-58

Student Readings

GEOLOGIC MAPPING

Lobeck, Armin K. *Things Maps Don't Tell Us: Adventure Into Map Interpretation.* New York: Macmillan Publishing Co., Inc., 1956.

Palmer, E. Lawrence, and H. Seymour Fowler. *Fieldbook of Natural History.* New York: McGraw-Hill Book Co., 1975.

White, Walter S. *Geologic Maps Portraits of the Earth.* Washington, DC: U. S. Geological Survey, 1975. (pamphlet).

MINERAL RESOURCES

American Gas Association. *The History of Natural Gas.* 3rd ed. Arlington, VA: American Gas Association, 1976. (pamphlet)

American Petroleum Institute. *New Frontiers for Energy.* Washington, DC: American Petroleum Institute, 1976.

Citizens' Advisory Committee on Environmental Quality. *Energy in Solid Waste.* Washington, DC: U. S. Government Printing Office, 1975.

Duncan, Donald C. *Oil Shale: A Potential Source of Energy.* Washington, DC: U. S. Geologic Survey, 1975. (pamphlet)

Gilmore, C. P. "How Science Will Help Us Get Rid of Our Mountain of Junk." *Popular Science,* April, 1971, pp. 71-73.

Josephy, Alvin M. Jr., and Terrence Moore. "Agony of the Northern Plains." *Audobon,* July, 1973, pp. 68-88

Nephew, E. A. "Healing Wounds." *Environment.* Jan. 1972, pp. 12-21

Petroleum Extension Service. *A Primer of Oil Well Drilling.* 3rd ed. Austin: Univ. of Texas, 1970.

White, Donald E. *Natural Steam for Power.* Washington, DC: U. S. Geological Survey, 1975. (pamphlet)

World Book of Encyclopedia. *Coal.* Washington, DC: National Coal Association, 1973. (reprint)

Mapping the Earth's Resources

Segment Synopsis

Students are introduced to the process of geologic mapping as they watch four geologists develop a geologic map for a small area in North Carolina's eastern piedmont. The team begins by researching what information is already available and recording it on a base map. The base map is then used to organize the party's field work in a systematic manner. Gena and Vaste determine the orientation of rock units by measuring the rock's strike and dip while Ron and Clay study rocks in another area and take notes. Samples, taken in the field, are later studied in the laboratory. This segment stresses the use of the scientific method and multiple hypotheses.

Concepts

- Natural forces acting today are the same as those which have been acting through the ages.
- The structure, texture, and composition of rocks reflect their origin and history.
- A geologic map is a graphic model representing the rock structure in a given area.
- Man's mind is his most important tool investigating the earth.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- relate the theory of uniformitarianism
- explain the mental processes involved in geologic mapping--specifically the concept of multiple working hypotheses
- outline the procedures involved in geologic mapping (i.e., strike and dip) and demonstrate their application to the mapping of rock structures.

Learning Activities

Introduce students to the idea of multiple working hypotheses and outline the definitions of the terms "strike" and "dip."

Have students compare topographic maps, aerial photographs, and geologic maps of the same area and list their similarities and differences.

You might wish to let the follow-up activities for this segment extend over several weeks so that they are completed just prior to viewing Program 29.

Have students complete the "Structural Mapping Laboratory" published by the Hubbard Scientific Company, Northbrook, Illinois.

Media Resources

FILMS

EARTH SCIENCE: THE EARTH'S INTERIOR. 16mm. 15 min. sd. color. Indiana Univ. Film Library, 1971.

THE ENERGY SEEKERS. 16mm. 24 1/2 min. sd. color. Society of Exploration Geophysicists.

WHAT'S INSIDE THE EARTH? 16mm. 14 min. sd. color. BFA Educational Media.

SLIDES

WHAT ON EARTH? SLIDE SET G/24/1.

Teacher References

American Geological Institute. 1965. *Geology: Science and Profession*. Washington: DC: American Geological Institute.

Earth Science Curriculum Project. 1968. *Geologic Field Study*. RS-9. Falls Church, VA: American Geological Institute.

The Problem of Mineral Resources

Segment Synopsis

THE PROBLEM OF MINERAL RESOURCES is a positive look at the mineral resource picture in today's world. Students are introduced to the idea of renewable and nonrenewable resources and the increased use of raw materials by our technological society. After visiting mines and oil drilling sites to discuss the limited nature of the earth's wealth, the possibility of recycling is suggested as one way of extending the world's wealth. Students visit auto-shredders and aluminum recycling centers; alternatives are discussed. Students then observe a pilot plant, operated by the U. S. Bureau of Mines which investigates the feasibility of recycling the refuse from entire cities and separating the usable fractions for resale as raw materials. Throughout the segment a positive approach to our resource problem is maintained, suggesting that there are ways to avoid the impending crisis.

Concept

- Man is rapidly exhausting the mineral resources of the earth and must take steps to conserve and recycle them.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain how man is using his mineral resources from a supply point of view
- explain at least one basic recycling scheme and relate recycling to the mineral resource supply-demand situation on the earth
- explain the earth as a "closed" system.

Learning Activities

Students should be introduced to the following terms prior to viewing this segment: resources, renewable, nonrenewable, conservation, recycling.

Have students give reports on the supplies of various mineral resources available for man's use and relate them to current use rates. Have them predict depletion dates for resources such as coal, oil, natural gas, copper, iron, etc.

Have students locate and report on recycling efforts in their community.

Have students conduct their own "Garbage Survey" using appropriate sampling techniques and scientific technology.

Have students conduct some of the activities outlined in Stephen M. Smith's ENERGY ENVIRONMENT MINI-UNIT GUIDE (1975), published by the National Science Teachers Association, Washington, D.C.

Encourage your students to join the President's Environmental Merit Awards Program (PEMAP). Write: PEMAP A-107, U. S. Environmental Protection Agency, Washington, D.C. 20460.

Media Resources

FILMS

CHALLENGE OF THE FUTURE. 16mm. 29 min. sd. color. U. S. Energy Research and Development Administration, 1975.

HOUSE OF MAN, I: OUR CHANGING ENVIRONMENT. 16mm. 17 min. sd. color. Ency. Britannica Ed. Corp. (produced by the Conservation Foundation)

NEW CONCEPT IN MINING. 16mm. 20 min. sd. color. Ideal Pictures Film Library.

OIL. 16mm. 18 min. sd. color. Shell Film Library, 1973.

RECYCLING ATLANTA. 16mm. 3 min. sd. color. Carbonated Beverage Container Manufacturers Association.

REFINERY PROCESS. 16mm. 20 min. sd. color. Shell Film Library.

THE TRANS-ALASKA PIPELINE. 16mm. 27 min. sd. color. Association - Sterling Films.

WASTE AWAY. 16mm. 22 min. sd. color. U. S. Dept. of Health, Education and Welfare.

Note: U. S. Bureau of Mines films are available dealing with numerous non-renewable resources and mineral resources of various states.

FILMSTRIPS

USING NATURAL RESOURCES. 6 color filmstrips. Ward's Natural Science Establishment, Inc.

SLIDES

WHAT ON EARTH? SLIDE SET G/24/2.

Teacher References

Dewall, Marilyn M. 1976. *NSTA Teachers Guide: Resource Materials for Environment and Energy*. Elementary Science Packet No. 12. Washington, D.C.: National Science Teachers Association. (pamphlet)

Grove, Noel. 1974. Oil, the dwindling treasure. *National Geographic* 145 (June): 792-825.

Kenahan, C. B., et al. 1973. *Bureau of Mines Research Programs On Recycling and Disposal of Mineral, Metal and Energy Based Wastes*. Information Circular 1973. Washington, DC: U. S. Bureau of Mines.

McCaull, Julian. 1972. The tide of industrial waste. *Environment* 14(Dec.): 30-40.

McClay, David R. 1973. *Natural Resources and Career Awareness: A Teacher's Guide for Grades K-6*. Washington, DC: U. S. Government Printing Office.

Putnam, John H. 1972. Quicksilver and slow death. *National Geographic* 142(Oct.): 506-527.

——————. 1974. Timber: how much is enough? *National Geographic* 145(April): 485-511.

Schatz, Albert. 1971. *Teaching Science with Garbage*. Emmaus, PA: Rodale Press, Inc.

Science Division. 1974. *Environmental Education: Strategies for Wise Use of Energy*. Raleigh: N. C. Dept. of Public Instruction.

Secretary of the Interior. 1972. *Mining and Mineral Policy*. Part 1. Washington, DC: U. S. Government Printing Office.

Sullivan, P. M.; and Stanezyk, M. H.; and Spendlove, M. J. 1973. *Resource Recovery from Raw Urban Refuse*. Report of Investigations 7760. Washington, DC: U. S. Bureau of Mines. (pamphlet)

Weaver, Kenneth F. 1977. Geothermal energy: the power of letting off steam. *National Geographic* 152(Oct.): 566-579.

Young, Gordon. 1970. Pollution, threat to man's only home. *National Geographic* 138(Dec.): 738-781.

25

Breaking Down the Rocks

Weathering and Soils
Water Underground

Program Overview

This program is divided into two parts. The first segment considers the processes of chemical and physical weathering and the soil that develops as an end product. It looks at soil profiles, soil use, and the problems of soil erosion. The second segment traces water as it moves through the earth. The terms porosity and permeability are introduced and water phenomena such as contact springs and artesian wells are shown. Students also see special features that result when ground water comes into contact with volcanically heated rocks or dissolves rocks in limestone areas.

Textbook References

- A SEARCH FOR UNDERSTANDING
    - Ch. 6-1: Weathering, pp. 182-196
    - Ch. 6-5: The Formation of Soil, pp. 200-203
    - Ch. 6-6: Conservation of Our Resources, pp. 205-207
    - Ch. 8-5: Waters Dissolve the Rocks, pp. 263-267
    - Ch. 9-2: Water in the Ground, pp. 273-278
- MODERN EARTH SCIENCE
    - Ch. 11: Weathering and Erosion, pp. 232-252
    - Ch. 12: Water and Rock, pp. 253-274
- PATTERNS IN OUR ENVIRONMENT
    - Ch. 8-4: Soil, p. 225
    - Ch. 6-15: Ground Water, p. 163
    - Ch. 6-16: Pore Spaces, p. 164
    - Ch. 6-17: Transpiration, pp. 164-165
- THE WORLD WE LIVE IN
    - Ch. 7: Weathering, Mass Wasting, and Soils, pp. 88-105
    - Ch. 8: Ground Water, pp. 106-121
- EARTH SCIENCE: A LABORATORY APPROACH
    - Ch. 2: The Treasure Beneath Our Feet, pp. 23-39
    - Ch. 3: The Key Role of Water on Spaceship Earth, pp. 41-54
    - Ch. 5-8: Water that Enters the Ground, pp. 90-91
    - Ch. 5-9: Our Water Resources, pp. 92-95
- EARTH SCIENCE: IIS
    - Idea 7-1: I'll Take Mine on the Rocks, pp. 241-244
    - Idea 7-2: Even Rocks Have Acid Indigestion, pp. 245-248
    - Idea 7-7: Have You Joined the Underground? pp. 267-272
- FOCUS ON EARTH SCIENCE
    - Ch. 6: Sedimentary Rocks, Parts 2-5, pp. 109-112
    - Ch. 14: Underground Water, pp. 270-285
- HOLT: EARTH SCIENCE
    - Ch. 7: Weathering, pp. 174-201

- INVESTIGATING THE EARTH
    - Ch. 9: The Land Wears Away, pp. 190-200, 206-209
    - Ch. 8: Moisture Income and Storage, pp. 168-176
- OUR ENVIRONMENT IN SPACE
    - Ch. 16: Energy Expanded at the Land-Atmosphere Interface, pp. 329-349
    - Ch. 17: The Energy of Flowing Water, pp. 351-373
- PATHWAYS IN SCIENCE
    - II Ch. 4: Weathering Changes the Earth's Surface, pp. 88-92
    - II Ch. 8: The Underground Water, pp. 109-114
    - II Ch. 9: Fighting the Battle of Erosion, pp. 115-119

Student Readings

Adams, George F., and Jerome Wyckoff. *Landforms.* New York: Western Publishing Co., 1971.

Alexander, Taylor R., and George S. Fichter. *Ecology.* New York: Western Publishing Co., 1973.

Allen, Dorothy H., and County Beautiful Magazine Editors. *Story of Soil.* New York: G. P. Putnam's Sons, 1971.

Baldwin, H. L., and C.L. McGuiness. *A Primer on Ground Water.* Washington, DC: U. S. Geological Survey, 1963. (pamphlet)

Bauer, Ernst W. *The Mysterious World of Caves.* New York: Franklin Watts, Inc., 1971.

Foth, H., and H. S. Jacobs. *Field Guide to Soils.* Boston: Houghton Mifflin Co., 1971.

Heady, Eleanor B. *The Soil that Feeds Us.* New York: Parents Magazine, 1972.

Leopold, L. B., and W. R. Longbain. *A Primer on Water.* Washington, DC: U. S. Geological Survey, 1960.

Rhine, Richard. *Life in a Bucket of Soil.* New York: Lothrop, Lee and Shepard Co., 1972.

Rhodes, Frank H. *Geology.* New York: Western Publishing Co., 1971.

Swanson, H. L., and C. L. McGuinness. *A Primer on Water Quality.* Washington, DC: U. S. Geological Survey, 1965. (pamphlet)

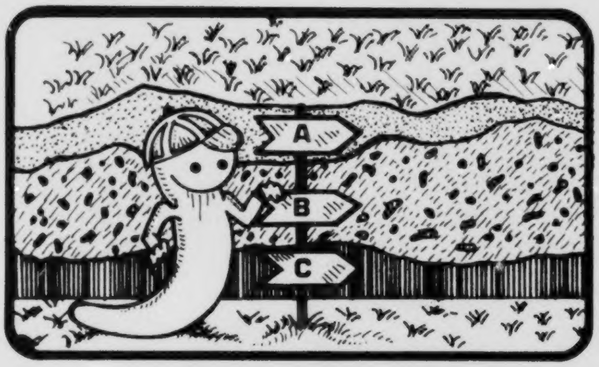
U. S. Geological Survey. *Geysers.* Washington, DC: U. S. Geological Survey, 1975. (pamphlet)

————. *Water in the Urban Environment: Erosion and Sediment.* Washington, DC: U. S. Geological Survey, 1974. (pamphlet)

————. *Water of the World.* Washington, DC: U. S. Geological Survey, 1975. (pamphlet)

Wentworth, Daniel F., et al. *Pollution: Examining Your Environment.* Minneapolis: Mine Publications, Inc., 1971.

25-1



Weathering and Soils

Segment Synopsis

This segment begins with fresh rock and examines the physical and chemical processes that reduce the rock to soil, first through frost wedging and wasting and then by solution, oxidation, and hydration. It shows the development of saprolite and residual and discusses what a soil profile is and the character of various horizons. The remainder of the segment is devoted to examples of ways in which soils are used and misused. Students see the damage that occurs when houses are built on the wrong type of soil. Dust bowl conditions and gullying are shown as examples of the misuse of land, sediment traps and stripcropping as examples of good conservation practice.

Concepts

- Natural forces acting today are the same as those which have been acting through the ages.
- Weathering is a chemical and physical process that alters and adjusts rocks and minerals to a surface environment different from that in which they were formed.
- The rate at which weathering proceeds depends on the composition of the materials involved and their response to the changing surface environment.
- If loosened rock material remains in place long enough, a mature soil will develop that reflects the climate of the area.
- Man is accelerating the erosion of the land by means of poor agricultural and engineering practices.

Objectives

After watching this segment and completing the appropriate follow-up activities, the student should be able to

- explain the theory of uniformitarianism as it relates to weathering and soil development
- explain the general process of weathering
- explain what a mature soil is, how it forms, and demonstrate a typical soil profile
- explain in general terms how climate and altitude affect the formation of soil
- illustrate several causes of soil erosion and give examples of preventive measures.

Learning Activities

Prior to viewing this segment, the students should be acquainted with the following terms: physical and chemical weathering, soil, erosion.

Have students bring samples of soil to class and compare them by physical differences such as color, texture, etc. Ask them to suggest reasons for the differences.

Have students collect samples of soil at home and send them to the state soil testing office for analysis. You can obtain the containers and forms from your county's agricultural extension agent.

Have students prepare displays illustrating one of the following topics:

1. Weathering--physical or chemical
2. How soil forms
3. The living layer (a horizon)
4. The profile of some local soil
5. Uses of soils
6. Soil conservation

Media Resources

FILMS

THE EARTH IS THE LORD'S. 16mm. 14 1/2 min. sd. color. Farm Film Foundation, 1960.

THE LIVING SOIL. 16mm. 20 min. sd. color. Shell Film Library.

SOIL: AN INTRODUCTION. 16mm. 8 1/2 min. sd. color. BFA Educational Media.

SOIL AND WATER CONSERVATION DEMONSTRATION. 16mm. 22 min. sd. color. Caterpillar Tractor Co., 1971.

SLIDES

WHAT ON EARTH? SLIDE SET G/25/1.

STUDY PRINTS

SOILS. 6 18" x 13" color prints. Ward's Natural Science Establishment, Inc.

TRANSPARENCIES

WEATHERING, MASS WASTING, SOIL AND GROUND WATER, AND RUNOFF. 15 b and w. transparencies. Ward's Natural Science Establishment, Inc.

Teacher References

Brady, Nyle C. 1974. *The Nature and Properties of Soils.* 8th ed. New York: Macmillan Publishing Co., Inc.

Foth, Henry D. 1970. *A Study of Soil Science.* Chestertown, MD: Lamotte Chemical Products Co.

Hunt, Charles B. 1972. *Geology of Soils: Their Evolution, Classification and Uses*. San Francisco: W. H. Freeman and Co.

Kellogg, Charles E. 1950. Soil. *Scientific American* 183(July): 30-39.

Schatz, Albert. 1971. *Teaching Science with Garbage*. Emmaus, PA: Rodale Press, Inc.

Soil Conservation Service. 1975. *Teaching Soil and Water Conservation.* Washington, DC: U. S. Dept. of Agriculture. (pamphlet)

U. S. Dept. of Agriculture. 1957. *The Yearbook of Agriculture, Soil.* Washington, DC: U. S. Government Printing Office.

25-2

Water Underground

Segment Synopsis

WATER UNDERGROUND is a tour of the magic land water has created beneath the earth's surface. The tour begins with a brief review of the water cycle. Then a demonstration of water movement underground illustrates porosity, permeability, water tables, and artesian aquifers. Springs, lakes, and swamps are explained in terms of their relationship to the water table. Geysers and hot springs are two special situations involving ground water in areas of igneous activity. Caverns, sinkholes, disappearing streams and natural bridges illustrate the kinds of landforms which develop when ground water interacts with limestone.

Concepts

- Natural forces acting today are the same as those which have been acting through the ages.
- Moving water is an important agent of erosion, acting both above and below ground.
- The interaction of internal and external processes may produce distinct landforms.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain the theory of uniformitarianism as it applies to ground water related phenomena
- illustrate the ways in which water moves through the ground
- explain how the water table relates to springs, swamps, and artesian wells and its role in the development of cavern systems and karst topography.

Learning Activities

Prior to viewing this segment, students should be acquainted with the following terms: porosity, capillarity, permeability, water table, artesian, spring, lake, swamp, cavern, sinkhole, geyser, hot spring, stalactite, stalagmite.

Have students collect pictures of various cavern systems and construct a display describing various caverns in the United States.

Have students locate several springs in their community.

During their study of ground water, have students conduct investigations of some of these topics: porosity, capillarity, permeability, water budgets, water purification, and water pollution tests.

Have students build models or construct displays illustrating one of the following topics: the water table; how over-pumping affects the watertable around a wall; artesian systems; springs; cavern development; and geysers, hot springs, and ground water.

Have students write for more information on caves and caving from the National Speleological Society, Cave Avenue, Huntsville, Alabama 35810.

Media Resources

FILMS

CAVERNS AND GEYSERS. 16mm. 14 min. sd. color. BFA Educational Media.

A DROP OF WATER. 16mm. 14 min. sd. color. Arthur Barr Productions, 1971.

THE RIVER MUST LIVE. 16mm. 21 min. sd. color. Shell Film Library, 1968.

THE SPELL OF THE CAVERNS. 16mm. 14 1/2 min. sd. color. Virginia Dept. of Conservation and Economic Development.

THE SUBJECT IS WATER. 16mm. 28 min. sd. color. U. S. Geological Survey, Visual Services Branch.

VIRGINIA SPECTACULAR. 16mm. 13 1/2 min. sd. color. Virginia Dept. of Conservation and Economic Development.

THE WATER BELOW. 16mm. 30 min. sd. color. U. S. Geological Survey, 1964.

WATER: THE COMMON NECESSITY. 16mm. 9 min. sd. color. Moody Institute of Science, 1975.

WATER: WHY IS IT WHAT IT IS? 16mm. 11 min. sd. color. Moody Institute of Science, 1975.

THE YEAR OF THE DISASTER. 16mm. 28 min. Caterpillar Tractor Co., 1967.

FILM LOOPS

GEYSERS AND HOT SPRINGS. 1 color film loop. Doubleday and Co., Inc. 1969.

HYDROGEOLOGY. 8 color film loops. Hubbard Scientific Co.

FILMSTRIPS

THE WATER SERIES. 6 filmstrips, 6 cassette tapes. Society for Visual Education, 1975.

SLIDES

WHAT ON EARTH? SLIDE SET G/25/2.

STUDY PRINTS

GROUND WATER. 6 18" x 13" color prints. Ward's Natural Science Establishment, Inc.

Teacher References

Earth Science Curriculum Project. 1969. *Basic Data and Water Budget Computation.* ESCP Reference Series, RS-8. Falls Church, VA: American Geological Institute.

Revelle, Roger. 1963. Water. *Scientific American* 209(Sept.): 24, 94-100.

26

Agents of Erosion

Streams Erode the Land
Glaciers Carve the Land
Waterfalls

Program Overview

This program is divided into three segments which look at the erosion of the earth's surface by water and ice. The first segment, STREAMS ERODE THE LAND, looks at the ways streams behave from their headwaters to their deltas. Stream flow, erosion, and deposition are illustrated through examples from across the United States. The second segment, GLACIERS CARVE THE LAND, uses active and former glacial areas in the United States and Canada to demonstrate how glaciers carve and change the land. The third segment, WATERFALLS, is a short film essay on the properties and magic of falling water.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 6-2: Transportation and Erosion, pp. 186-190
  - Ch. 6-3: Glaciers, pp. 190-196
  - Ch. 7: The Earth's Surface is Built-Up, pp. 214-223
  - Ch. 8: The Work of Moving Water, pp. 242-267
- MODERN EARTH SCIENCE
  - Ch. 12: Water and Rock, pp. 253-274
  - Ch. 13: Ice and Rock, pp. 275-295
- PATTERNS IN OUR ENVIRONMENT
  - Ch. 8-5: Up-down-up-down: The Building Up and Wearing Down of Landscapes, pp. 226-229
  - Ch. 8-6: Erosion, pp. 229-232
- THE WORLD WE LIVE IN
  - Ch. 10: Running Water, pp. 130-156
  - Ch. 11: Glaciers, pp. 157-178
- EARTH SCIENCE: A LABORATORY APPROACH
  - Ch. 6: The Changing Face of the Land, pp. 101-133
  - Ch. 7-1: Rivers of Ice, pp. 135-137
  - Ch. 7-2: Half of the Earth Under a Blanket of Ice, pp. 137-138
- EARTH SCIENCE: IIS
  - Idea 7-3: Old Man River Was Once Young, pp. 249-254
  - Idea 7-5: It's White, But It's Not a Tornado, pp. 259-262
  - Idea 8-1: Here Today, Lagoon Tomorrow, pp. 277-282
  - Idea 8-2: Watch Out for the Drumlins, pp. 283-286
- FOCUS ON EARTH SCIENCE
  - Ch. 13: Mass Movements and Running Water, pp. 250-269
  - Ch. 15: Glaciers, pp. 286-305
- HOLT: EARTH SCIENCE
  - Ch. 3: Shaping the Land, pp. 64-96

- INVESTIGATING THE EARTH
  - Ch. 9-7 through Ch. 9-10: Erosion, pp. 201-208
- OUR ENVIRONMENT IN SPACE
  - Ch. 17: The Energy of Flowing Water, pp. 351-376
  - Ch. 18: Work of Glacial Ice Upon the Lands, pp. 377-392
- PATHWAYS IN SCIENCE
  - II Ch. 5: Wind and Water Change the Earth's Surface, pp. 93-97
  - II Ch. 6: Glaciers--The Force of Moving Ice, pp. 98-103
  - II Ch. 7: Water, Water, Everywhere, pp. 104-108

Student Readings

GENERAL

Adams, George F., and Jerome Wyckoff. *Landforms*. New York: Western Publishing Co., Inc., 1971.

Rhodes, Frank H. *Geology*. New York: Western Publishing Co., Inc., 1971.

STREAMS AND WATERFALLS

Breed, Jack. "Land of the Havasupai (Arizona Indians)." *National Geographic*, May 1948, pp. 655-674.

Challacombe, J. R. "The Fabulous Sierra Nevada." *National Geographic*, June 1954, pp. 825-843.

Davis, Kenneth S., and Luna Leopold. *Water*. New York: Time-Life, Inc., 1970. (a title in the Life Science Laboratory series)

Edwards, Walter Maeyers. "Niagara Falls, Servant of Good Neighbors." *National Geographic*, April 1963, pp. 574-587.

Kennedy, Leonard. "The World's Greatest Waterfall: The Kaieteur Falls, in British Guiana." *National Geographic*, Sept. 1911, pp. 846-859.

Noyes, Theodore W. "The World's Great Waterfalls: Visits to Mighty Niagara, Wonderful Victoria, and Picturesque Iguazu." *National Geographic*, July 1926, pp. 29-59.

GLACIERS

Dyson, James. *The World of Ice*. New York: Alfred M. Knopf, Inc., 1962.

Kurten, Bjorn. *The Ice Age*. New York: G. P. Putnam's Sons, 1972.

Lauber, Patricia. *Icebergs and Glaciers*. Canaan, CT: Garrard Publishing Co., 1961. (a title in the Junior Science Book series)

Jones, William R., and David Muench. *Yosemite, The Story Behind the Scenery*. Las Vegas: K. C. Publications, 1971.

Matthews, William H., III. *The Story of Glaciers and the Ice Age*. New York: Harvey House, Inc., 1974.

26-1

Streams Erode the Land

Segment Synopsis

STREAMS ERODE THE LAND traces water from the point where it first strikes the earth until it enters the sea. It discusses the erosional processes of abrasion, saltation, and solution and illustrates the potholes and waterfalls that result from turbulent water and high gradient streams. The segment is divided into four parts. The first three discuss high gradient "youthful" streams, medium gradient "mature" streams, and low gradient "old age" streams, whereas the final part illustrates the phenomenon of rejuvenation. Each part explains and illustrates the creation of typical stream profiles. This segment also pays special attention to erosion and deposition phenomena, watershed development and man's use and misuse of streams.

Concepts

- Natural forces acting today are the same as those which have been acting through the ages.
- Gravity moves weathered material to lower elevations and ultimately to the sea through the media of water, wind, and ice.
- Moving water is the chief leveling agent.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain the theory of uniformitarianism
- explain how water erodes the land and cite some well known examples.

Learning Activities

Before viewing this segment, either students should be introduced to the following terms or the film segment itself may introduce the terms, aided by a follow-up discussion: gradient, youthful, mature, meandering, levee, pothole, delta, alluvial fan, flood plain, back swamp, tributary, divide, water gap, wind gap.

Have students prepare a county map (road map) using colored markers to show divides and watersheds. The map can be expanded into a display with student photographs of local stream profiles and features.

Have students prepare a bulletin board using photographs to illustrate high-gradient, medium-gradient, and low-gradient streams.

Have students conduct the following investigations from F. Martin Brown and Rem W. Thompson's TOPOGRAPHIC MAPS FOR EARTH SCIENCE (1970), published by Silver Burdett Company, Morristown, New Jersey:

5 Streams I, pp. 9-10
6 Streams II, pp. 11-12
7 Streams III, pp. 13-14
8 Deltas, pp. 15-16
18 Drainage Patterns, pp. 35-36

Have students use a stream table to simulate various stream phenomena. See Joseph D. Exline's INDIVIDUALIZED TECHNIQUES FOR TEACHING EARTH SCIENCE (1975), published by Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Have students take pictures of examples of erosion near the school. In the case of gullies and similar features, they may wish to photograph a feature at monthly intervals and compare the results.

Have students construct profiles of streams near school, using topographic maps, and classify the streams based on observable features.

Media Resources

FILMS

EROSION: LEVELING THE LAND. 16mm. 14 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

FLOOD. 16mm. 15 min. sd. color. National Oceanic and Atmospheric Administration.

FLOOD BELOW. 16mm. 16 min. sd. color. National Aeronautics and Space Administration, 1975.

THE GREAT FLOOD OF 1973. 16mm. 25 min. sd. color. U. S. Army Engineer District, St. Paul, 1974.

GREAT RIVER. 16mm. 28 min. sd. color. Bonneville Power Administration, 1973.

HELLS CANYON. 16mm. 26 min. sd. color. Idaho Dept. of Commerce and Development.

JOHN WESLEY POWELL: CANYON GEOLOGIST. 16mm. 20 min. sd. color. U. S. Geological Survey.

LEGENDS OF THE LODORE. 16mm. 13 min. sd. color. Colorado State Division of Commerce and Development.

NINETY DAYS TO SURVIVAL. 16mm. 52 min. sd. color. Pyramid Films. (a Smithsonian Institution film produced by CBS News)

RAPIDS OF THE COLORADO. 16mm. 15 min. sd. color. Pyramid Films.

THE RIVER MUST LIVE. 16mm. 21 min. sd. color. Shell Film Library, 1968.

RIVERS IN MINIATURE. 16mm. 14 min. sd. color. U. S. Army Engineer Waterways Experiment Station, 1954.

RIVERS OF NO RETURN. 16mm. 28 min. sd. color. Idaho Dept. of Commerce and Development.

SEA RIVER. 16mm. 14 min. sd. color. U. S. Geological Survey.

THE WAYS OF WATER. 16mm. 13 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

SLIDES

WHAT ON EARTH? SLIDE SET G/26/1.

TRANSPARENCIES

WORK OF STREAMS: THE EROSION CYCLE. 15 b and w transparencies. Ward's Natural Science Establishment, Inc.

MODELS

STREAMTABLE. 70" x 26" x 6" table. Ward's Natural Science Establishment, Inc.

GEOMORPHOLOGICAL MODEL SET. 8 models. Ward's Natural Science Establishment, Inc.

Teacher References

Craighead, Frank, Jr., and Craighead, John. 1970. White-water adventure on wild rivers of Idaho. *National Geographic* 137(Feb.): 213-239.

Edwards, Mike W. 1970. Shenandoah, I long to hear you. *National Geographic* 137 (April): 554-588.

Morgan, James P. 1970. Deltas: a resume *Journal of Geological Education* 18 (3): 107-116.

Shepard, F. P., and Wanless, H. R. 1971. *Our Changing Coastlines*. New York: McGraw-Hill Book Co.

26-2

Glaciers Carve the Land

Segment Synopsis

This segment, GLACIERS CARVE THE LAND, introduces students to the process of glaciation and the erosional landforms produced by moving ice. Although continental glaciers are mentioned, the majority of the segment is devoted to alpine glaciation. Film from Alaska and Baniff National Park in Alberta, Canada provides students with a firsthand look at active glaciers both in terms of ice movement and erosional products. A walk filmed in Rock Creek, Montana introduces students to glacial features left by a retreating glacier. Footage of Yosemite Valley serves to illustrate the power of moving ice. Students will see gigantic results produced by alpine glaciers in the Rockies, and observe smaller features produced by moving ice. The segment's overall aim is to introduce students to the power of glacial action and the resulting erosion.

Concepts

- Natural forces acting today are the same as those which have been acting through the ages.
- Gravity moves weathered material to lower elevations and ultimately to the sea through the media of water, ice, and wind.
- If the climate permits, moving ice (glaciers) erodes and transports rock and soil to a warmer area, where the ice melts and deposits the material it has carried.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain the glacial evidence for the theory of uniformitarianism
- describe one of the four major methods of erosion
- cite several major examples of glacial features in the United States

Learning Activities

Before viewing this segment, either students should be introduced to the following terms or the film segment itself may introduce the terms, aided by follow-up discussion: glacier, till, cirque, knife-edged ridge, horn, kettle lake, crevice.

Have students collect photographs of active glaciers and glacial valleys and use them to create a display illustrating ways in which moving ice carves rock.

Have students make a display showing the location of active glaciers and glacially scarred areas in North America.

Have students investigate the concept of flowing ice. Begin by placing crushed ice in a pipe that has a small hole drilled in its side. Close the pipe by inserting close fitting wooden dowels in each end. Place the entire unit in a vise and slowly apply pressure to the dowels. Ask students to explain what they believe is taking place. As an alternative to this activity, place a block of ice on a hard, cold flat surface. Cover the block with a second flat plate and add weight slowing beginning with one-minute intervals. Ask students to describe and explain what they see happening to the ice.

Invite knowledgeable individuals in your area who have visited or worked in glacial areas to show slides and describe glacial country to your class.

Have students conduct the following investigations from F. Martin Brown and Rem W. Thompson's TOPOGRAPHIC MAPS FOR EARTH SCIENCE (1970), published by Silver Burdett Co., Morristown, New Jersey:

11 Ice Fields and Alpine Glaciers, pp. 21-22
12 Alpine Glaciation, pp. 23-24
13 Continental Glaciation, pp. 25-26
14 Drumline, pp. 27-28

Media Resources

FILMS

EARTH SCIENCE: LEGACIES OF THE ICE AGE. 16mm. 12 min. sd. color. Indiana Univ. Film Library.

EVIDENCE FOR THE ICE AGE. 16mm. 19 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

GEOLOGICAL WORK OF ICE. 16mm. 11 min. sd. color. Ency. Britannica Ed. Corp. (2nd ed.)

GLACIER ON THE MOVE. 16mm. 11 min. sd. color. Ency. Britannica Ed. Corp. (from the AGI/EBE Earth Science Program)

RIVER OF ICE: LIFE CYCLE OF A GLACIER. 16mm. 10 min. sd. color. BFA Educational Media. (2nd ed.)

THE STORY OF TWO CREEKS. 16mm. 30 min. sd. color. Univ. of Wisconsin Film Library, 1969.

FILMSTRIP

INVESTIGATING A GLACIER. 1 color filmstrip. Ency. Britannica Ed. Corp.

SLIDES

GLACIAL EROSION AND DEPOSITION. 20 color slides. Ward's Natural Science Establishment, Inc.

WHAT ON EARTH? SLIDE SET G/26/2.

MODEL

ALPINE GLACIER MODEL. 18" x 24" model. Hubbard Scientific Co.

Teacher References

Crandell, Dwight R. 1969. *Surficial Geology of Mount Ranier National Park, Washington.* U. S. Geological Survey Bulletin 1288. (map)

Flint, Richard F. 1971. *Glacial and Quaternary Geology.* New York: John Wiley and Sons, Inc.

Kirk, Ruth. 1968. *Exploring Mount Ranier.* Seattle: Univ. of Washington Press.

LaBastille, Anne. 1977. On the trail of Wisconsin's ice age. *National Geographic* 152 (Aug.): 182-205.

Matthes, Francois E. 1950. *The Incomparable Valley: A Geologic Interpretation of the Yosemite.* Berkeley: Univ. of California Press.

Poulsen, Mogens Bloch. 1973. Greenland's place by the icebergs. *National Geographic* 144(Dec.): 849-869.

Raymond, Loren H. 1977. Glacial, periglacial and pseudo-glacial features. *Southeastern Geology* 18(4): 213-229.

Shapp, Robert. 1960. *Glaciers.* Eugene: Univ. of Oregon Press.

U. S. Geological Survey. *The Great Ice Age.* Washington, DC: U. S. Government Printing Office. (pamphlet)

Yandell, Michael D., and Yandell, Edward R. 1974. *National Parkways: A Photographic and Comprehensive Guide to Glacier and Waterton Lakes National Parks.* Casper: WY: Worldwide Research and Publishing Co.

Waterfalls

Segment Synopsis

WATERFALLS is a short film essay set to music that strives to depict falling water both as a thing of beauty and as a landshaping force. Students will see waterfalls in all sizes and from many places in the Eastern and Western United States. A very brief narration introduces the causes of waterfalls and describes their features. Among the waterfalls depicted are glacially caused forms such as Yosemite and Bridal Veil Falls, ground water-related waterfalls at Thousand Springs in Idaho, and structurally caused falls at Uray, Colorado; Rock Creek, Montana; Spearfish, South Dakota; and Hanging Rock, North Carolina.

Concepts

- Natural forces acting today are the same as those which have been acting through the ages.
- Gravity moves weathered material to lower elevations and ultimately to the sea through the media of water, ice, and wind.
- Moving water is the chief leveling agent.

Objective

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain how water erodes the land in the special case of waterfalls.

Learning Activities

Have students find the definition of a waterfall in dictionaries and encyclopedias.

Conduct a poetry writing project in cooperation with the language arts teachers. Have students write poems or search for poems and short stories about waterfalls.

Have students look for works of art depicting falling water and music written about falling water.

Conduct a bulletin board contest in which the group that designs the most artistic, imaginative display will then put it up on a centrally located bulletin board.

Media Resources

FILM

WATERS OF YOSEMITE. 16mm. 9 min. sd. color. Pyramid Films.

SLIDES

WHAT ON EARTH? SLIDE SET G/26/3.

Teacher References

Pearl, Richard M. 1974. Waterfalls: an explanation. *Earth Science* 27(March-April): 94-101.

U. S. Geological Survey. 1974. *The River and the Rocks*. Washington, DC: U. S. Government Printing Office. (pamphlet)

27

Sedimentary Rocks

The Stories That Rocks Tell
What is a Fossil?

Program Overview

This program is comprised of two segments. The first, THE STORIES THAT ROCKS TELL, looks at sedimentary rocks to find out how they are formed and how they offer evidence of the conditions which existed at the time they were formed. The second segment, WHAT IS A FOSSIL? explores the processes that allow life forms to be presented as fossils and studies the techniques paleontologists use to find fossils.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 3-5: Some Ways of Identifying Common Rocks, pp. 106-110
  - Ch. 7: The Earth's Surface is Built Up, pp. 209-223
  - Ch. 11: The Language of the Rocks, pp. 342-355
- MODERN EARTH SCIENCE
  - Ch. 8: Materials of the Earth's Crust, pp. 153-181
  - Ch. 18: The Rock Record, pp. 376-395
- PATTERNS IN OUR ENVIRONMENT
  - Ch. 5-11: Sedimentary Rocks, p. 122
  - Ch. 5-12: Sediments, pp. 122-124
  - Ch. 5-13: Clues of the Past in Sedimentary Rocks, p. 125
- THE WORLD WE LIVE IN
  - Ch. 5: Origin of the Rocks, pp. 47-71
  - Ch. 23: The Rock Record, pp. 324-338
- EARTH SCIENCE: A LABORATORY APPROACH
  - Ch. 6-7: Rocks Formed from Sedimentary Deposits, pp. 127-128
  - Ch. 7-8: Fossils and Similar Deposits, pp. 151-153
- EARTH SCIENCE: IIS
  - Idea 4-4: We Have to Settle this Now, pp. 137-142
  - Idea 4-5: The Rock Connection, pp. 143-146
  - Idea 8-7: Collecting the Past, pp. 311-316
  - Idea 8-8: The Big Push, pp. 317-320
- FOCUS ON EARTH SCIENCE
  - Ch. 6: Sedimentary Rocks, pp. 108-126
- HOLT: EARTH SCIENCE
  - Ch. 4: Earth History, pp. 97-130
  - Ch. 6: Rocks, pp. 153-173
- INVESTIGATING THE EARTH
  - Ch. 2-3: Investigating Rocks and Minerals, p. 30.
  - Ch. 16: The Record in the Rocks, pp. 343-362
  - Ch. 17: Life: Present, Past, and Future, pp. 366-378

- OUR ENVIRONMENT IN SPACE
  Extending Unit 4: Sedimentary Rocks, pp. 438-440
  Ch. 24: Energy Systems Throughout the Geologic Time, pp. 509-515

- PATHWAYS IN SCIENCE
  I Ch. 4: Rocks from the Waters, pp. 20-25
  Unit III: The Story Told by Rocks, pp. 137-176

Student Readings

GENERAL

Fenton, Carroll Lane, and Mildred Adams Fenton. *The Rock Book.* New York: Doubleday and Co., Inc., 1970.

Martin, Alice and Bertha M. Parker. *Rocks and Minerals.* New York: Western Publishing Co., Inc., 1974.

Rhodes, Frank H. *Geology.* New York: Western Publishing Co., Inc., 1971.

FOSSILS

Cartner, William C. *How We Know What on Earth Happened Before Man Arrived.* New York: Sterling Publishing Co., 1972.

Cohen, Daniel. *The Age of Giant Mammals.* New York: Dodd, Mead and Co., 1969.

Goldring, Winifred. *Handbook of Paleontology for Beginners and Amateurs: The Fossils, Part I.* Ithaca: Paleontological Research Institution, 1960.

Ipsen, D. C. *The Riddle of the Stegosaurus.* New York: Addison-Wesley Publishing Co., Inc., 1969.

Keen, Martin L. *Hunting Fossils.* New York: Julian Messner, Inc., 1970.

Lanham, Urless. *The Bone Hunters.* New York: Columbia Univ. Press, 1973.

Major, Alan. *Collecting Fossils.* New York: St. Martin's Press, 1975.

Martin, Alice F., and Bertha M. Parker. *Dinosaurs.* New York: Western Publishing Co., Inc., 1973.

Pinn, Giovanni. *The Dawn of Life.* London: Orbis Publishing Co., 1972.

Prehistoric Animals: The 1976 Child Craft Annual. New York: Field Enterprises, 1976.

Ross, Wilda. *What Did the Dinosaurs Eat?* New York: Coward, McCann, and Geoghegan, Inc., 1972.

Shuttlesworth, Dorothy. *To Find a Dinosaur.* New York: Doubleday and Co., Inc., 1973.

Silverberg, Robert. *Mammoths, Mastadons and Man.* New York: McGraw-Hill Book Co., 1970.

White, Theodore E. *Dinosaurs at Home.* New York: Vantage Press, 1967.

Zappler, Lisbeth, and George Zappler. *The World After the Dinosaur: The Evolution of Mammals.* New York: Natural History Press, 1970.

National Museum of Natural History. *Ice Age Mammals and the Emergence of Man.* Washington, DC: Elephant Press, Smithsonian Institution. n.d.

27-1

The Stories That Rocks Tell

Segment Synopsis

THE STORIES ROCKS CAN TELL shows how sedimentary rocks contain evidence of their origin. The segment begins by discussing the processes of deposition, compaction, and cementation that produce sedimentary rock. It considers the environmental conditions that produce particular rock types. Conglomerates are shown to be a product of abrupt changes in stream velocity; sandstones, a result of a variety of sand deposition patterns of wind and water. Students observe swamps that produce shale and coal and two structures that reflect short term events: raindrop impressions and drought produced mud cracks. Coquina originates from the crushing of shell beds by breaking waves. Lime secretion results in coral reefs and shell limestones. The segment depicts the conditions necessary for creating evaporites and preserving fossils. The conclusion suggests that students too, can read the story of depositional environments in sedimentary rocks.

Concepts

- Natural processes acting today are the same as those which have been acting through the ages.
- Sedimentary rocks are formed by compaction and cementation of various products of erosion.
- Sedimentary rocks and the features they contain reflect the conditions that existed during the time they were deposited.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- relate the formation of sedimentary rocks and the features preserved in them to the theory of uniformitarianism
- explain how the most common types of sedimentary rocks are formed and the depositional environments they reflect
- identify specific features in sedimentary rocks that are used as evidence to determine depositional conditions.

Learning Activities

Prior to viewing this segment, students should be acquainted with the following terms: sediment, compaction, cementation, environment, fossils, sedimentary rock.

Have students study a group of specimens and try to decide what kinds of depositional conditions they represent. Repeat after viewing segment.

Media Resources

FILM

ROCKS THAT REVEAL THE PAST. 16mm. 12 min. sd. color. BFA Educational Media.

FILM LOOP

SEDIMENTARY ROCKS. 1 color film loop. Hubbard Scientific Company.

FILMSTRIPS

MATERIALS OF THE EARTH'S CRUST. 6 color filmstrips. Ward's Natural Science Establishment, Inc.

ROCKS AND MINERALS: SEDIMENTARY ROCKS. 1 color filmstrip, cassette tape/disc recording. Learning Resources, 1974.

SLIDES

ROCKS. 20 color slides. Hubbard Scientific Co.

KIT

EARTH MATERIALS KIT. quantities of 25 specimens. Hubbard Scientific Co.

MAPS

Upton, William B. 1970. LANDFORMS AND TOPOGRAPHIC MAPS. New York: John Wiley and Sons, Inc.

Teacher References

Blatt, Harvey; Middleton, Gerard; and Murray, Raymond. 1972. *Origin of Sedimentary Rocks.* Englewood Cliffs, NJ: Prentice-Hall, Inc.

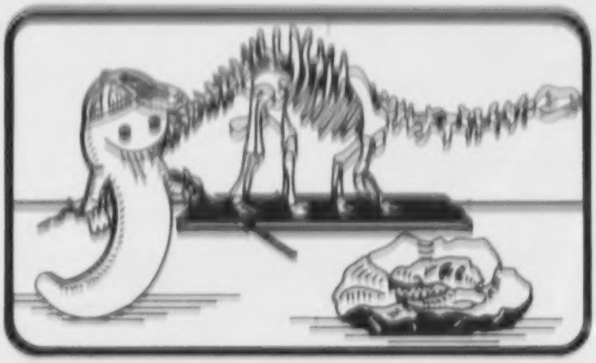
Morgan, James P. 1970. Deltas: a resume. *Journal of Geological Education* 18(3): 107-117.

Newell, Norman D. 1972. The evolution of reefs. *Scientific American* 226(12): 54-65.

Pirsson, Louis V., and Knopf, Adolph. 1953. *Rocks and Rock Minerals.* 3rd ed. New York: John Wiley and Sons, Inc.

Strahler, Arthur N. 1971. *Principles of Physical Geology.* 2nd ed. New York: Harper and Row.

27-2



What is a Fossil?

Segment Synopsis

WHAT IS A FOSSIL? introduces students to fossil preservation and the profession of paleontology. The segment begins in the Badlands of South Dakota with the "discovery" of an oreodont skull and then proceeds to a discussion of various types of preservation and indirect evidence of fossil life forms. Examples are seen of carbon traces of plants, traces of dinosaurs, silica replaced wood and shells, pyritized shells, amber preservation, cast and molds, and mummification. Students observe paleontologists at Dinosaur National Monument exposing the bones of large dinosaurs. Students also watch Dr. Jim Jenson supervise the removal of giant bones from a quarry near Grand Junction, Colorado. The final portion of the segment takes students to the laboratories of the Smithsonian Institution where a fossil is followed from its arrival, through its preparation and completion as a specimen ready for study or display.

Concepts

- Natural processes acting today are the same as those which have been acting through the ages.
- Fossils occur in sedimentary rocks in a number of ways.
- Fossils commonly reflect past environments.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- relate the presentation of fossils to the theory of uniformitarianism
- explain the principle methods by which fossils are preserved
- explain and illustrate how fossils serve as indicators of the environment in which they lived.

Learning Activities

Prior to viewing this segment, students should be acquainted with the following terms: fossil, paleontologist, replacement.

Have students prepare a bulletin board display which shows some of the ways fossils are preserved.

Conduct an art contest in cooperation with the art teacher. Have students research and then prepare drawings of plants and animals as they would have appeared during a particular period of geologic time.

Have students conduct the following investigations from Mile F. Harris's, et al. Earth Science Curriculum Project textbook, INVESTIGATING THE EARTH (1973), published by Houghton Mifflin Company, Boston, Massachusetts:

17-4 Fossil Evidence for Prehistoric Organisms
17-5 Investigating Footprint Puzzle
17-6 How Fossils Form
17-7 Investigating Casts and Molds

Have students try being paleontologists by carrying out the activity described in Richard Lauricell's "Paleontology in the Classroom," in SCIENCE AND CHILDREN, Vol. 14, No. 6 (March, 1977), p. 6. Then research whether dinosaurs were warm or cold blooded animals.

A group of students may wish to try mounting the bones of a chicken (less head and feet) using the remains of a baking hen from one of their homes.

Media Resources

FILMS

DINOSAURLAND. 16mm. 25 min. sd. color. Utah Travel Council.

DINOSAURS: THE AGE OF THE TERRIBLE LIZARD. 16mm. [illegible] min. sd. color. Ency. Britannica Ed. Corp., 1970.

THE FOSSIL STORY. 16mm. 19 min. sd. color. Shell Film Library, 1963.

FOSSIL FROM SITE TO MUSEUM. 16mm. 11 min. sd. color. Coronet Films, 1971.

THE GREAT DINOSAUR DISCOVERY. 16mm. 25 min. sd. color. Brigham Young Univ., 1976.

FILM LOOPS

FOSSILS, PARTS I AND II. 2 color film loops. Ward's Natural Science Establishment, Inc.

SLIDES

INTRODUCTION TO FOSSILS, PARTS I AND II. 20 color slides in each part. Society for Visual Education, 1972.

WHAT ON EARTH? SLIDE SET. [illegible]

STEREO STUDY PRINTS

Sandberg, Philip. STEREOGRAM BOOK OF FOSSILS. [illegible] color prints. Hubbard Scientific Co.

WEIGART EMBOSSED FOSSIL REPRODUCTIONS. Museum Shops, Smithsonian Institution.

Zallinger, Rudolph F. DINOSAUR AND MAMMAL MURALS. 9' x 1 1/2' color prints. Peabody Museum Associates, Yale Univ.

KITS

BASIC FOSSIL COLLECTION 16 fossils, Ward's Natural Science Establishment, Inc.

BASIC FOSSIL KIT. 20 plastic fossils. Hubbard Scientific Co.

Teacher References

Andrews, Henry N., Jr., 1947. *Ancient Plants and the World They Lived In.* Ithaca, NY: Comstock Publishing Associates.

Ash, Sidney R., and May, David B., 1969. *Petrified Forest: The Story Behind the Scenery.* Holbrook, AZ: Petrified Forest Museum Association.

Beerbower, J. R. *Field Guide to Fossils.* ESCP Pamphlet Series No. 4. Boston: Houghton Mifflin Co.

Callahan, Philip S. 1972. *The Evolution of the Insects.* New York: Holiday House, Inc.

Colbert, Edwin H. 1966. *The Age of Reptiles.* New York: W. W. Norton and Co., Inc.

Desmond, Adrian. 1976. *Hot Blooded Dinosaurs: A Revolution in Paleontology.* New York: Dial Press.

Dunbar, Carl O., and Waage, Karl M. 1969. *Historical Geology.* 3rd ed. New York: John Wiley and Sons, Inc.

Fenton, Carroll L., and Fenton, Mildred A. 1959. *Fossil Book.* Garden City, NY: Doubleday and Co., Inc.

Glut, Doland F. 1972. *The Dinosaur Discovery.* Secaucus, NJ: Citadel Press.

Markman, Harvey C. 1952. *Fossil Mammals: Museum Pictorial No. 4.* Denver, CO: Denver Museum of Natural History.

Spinar, Z. V. 1972. *Life Before Man.* New York: McGraw-Hill Book Co.

Stewart, John Massey. 1977. Frozen mammoths from Siberia bring the ice ages to vivid life. *Science* 8(9): 60-69.

Tidwell, William D. 1975. *Common Fossil Plants of Western North America.* Provo, UT: Brigham Young Univ. Press.

28

Landforms

What is a Landform?
Man vs. the Land

Program Overview

The interaction of constructive and destructive forces that result in landforms is the basic theme of this program. The first segment, WHAT IS A LANDFORM?, considers the phases of the landform cycle by comparing mountains, plains, and plateaus in "youth," "maturity," and "old age." Students are encouraged to look at the way man uses the land in light of its geologic structure and history. In the second segment, MAN VS. THE LAND, students are asked if man is behaving as a climax or pioneer species. The history of a plant community and an ancient Indian community are used as examples to help students arrive at a conclusion.

Textbook References

- A SEARCH FOR UNDERSTANDING
    Ch. 2: A Look at the United States, pp. 48-82
    Ch. 7-4: Mountains, pp. 223-231
- MODERN EARTH SCIENCE
    No references
- PATTERNS IN OUR ENVIRONMENT
    Ch. 8-3: Landscape Patterns--How Are They Formed?, pp. 221-225
    Ch. 8-5: Up-down-up-down: The Building Up and Wearing Down of Landscapes, pp. 226-229
    Ch. 8-7: People and Landscapes, pp. 229-232
- THE WORLD WE LIVE IN
    Ch. 14: Mountains, Plateaus, and Plains, pp. 207-225
    Ch. 17: Physiographic Provinces of the United States, pp. 247-254
- EARTH SCIENCE: A LABORATORY APPROACH
    No references
- EARTH SCIENCE: IIS
    No references
- FOCUS ON EARTH SCIENCE
    No references
- HOLT: EARTH SCIENCE
    Ch. 2: Bending the Crust, pp. 43-63.
    Ch. 3: Shaping the Land, pp. 64-96
    Ch. 8: People Resources and Energy, pp. 202-240
- INVESTIGATING THE EARTH
    Ch. 14: Evolution of Landscapes, pp. 299-318
- OUR ENVIRONMENT IN SPACE
    No references
- PATHWAYS IN SCIENCE
    No references

Student Readings

Adams, George F., and Jerome Wyckoff. *Landforms.* New York: Western Publishing Co., Inc., 1971.

Alexander, Taylor R., and George S. Fichter. *Ecology.* New York: Western Publishing Co., Inc., 1973.

Chronic, John and Halka. *Prairie Peak and Plateau, A Guide to the Geology of Colorado.* Bulletin 32. Denver: Colorado Geological Survey, 1972.

"Cities of First Americans" *Arizona Highways* 48, No. 1 (1972), 16-33.

Clark, William. *Death Valley: The Story Behind the Scenery.* Las Vegas: K. C. Publications, 1972.

Love, J. D., and John C. Reed, Jr. *Creation of the Teton Landscape.* Jackson, WY: Grand Teton Natural History Association, 1968.

National Geographic Society. *Our Continent: A Natural History of North America.* Washington, DC: National Geographic Society, 1976.

Phillips, M. V. *Physical Geography, Interpreting the Physical Features of the Earth.* Middletown, CT: American Education Publications, 1976.

Shimer, J. A. *Field Guide to Landforms in the United States.* New York: Macmillan Publishing Co., Inc., 1972.

Time-Life Editors. *The American Wilderness.* Morristown, NJ: Silver Burdett Co., 1972-1975. (a series of titles about areas in the United States)

U. S. Geological Survey. *Landforms of the United States.* Washington, DC: U. S. Government Printing Office, 1975. (pamphlet)

__________. *Our Changing Continent.* Washington, DC: U. S. Government Printing Office, 1973. (pamphlet)

Watts, May T. *Reading the Landscape.* New York: Macmillan Publishing Co., Inc., 1957.

Yandell, Michael D. *National Parkways, a Photographic and Comprehensive Guide to Rocky Mountain and Mesa Verde National Parks.* Casper, Wyoming: Worldwide Research and Publishing Co., 1975.

Zim, Herbert S. *The Rocky Mountains.* New York: Western Publishing Co., Inc., 1964.

28-1

What is a Landform?

Segment Synopsis

This segment introduces students to the idea that landforms and the kinds of activities man can carry out upon them are determined by the history of geologic events in the area. The Black Hills of South Dakota are considered as an example. Students are taken through a brief review of the Hills' history and then look at the Hills today in terms of their features and the kinds of activities man carries out in the region. The segment introduces major landforms, beginning with mountains and plateaus. It shows the Alleghany and Colorado Plateaus, landforms caused by different climates; the Great Plains; and the Atlantic Coastal Plain. Throughout the segment, landform development is stressed as a process primarily involving uplift and erosion.

Concepts

- Natural forces acting today are the same as those which have been acting through the ages.
- The landscape may be considered the product of internal versus external processes working on rocks exposed at the interface.
- The structure, texture, and composition of rocks reflect their origin and history.
- Internal and external processes vary in different places and at different times.
- The interaction between internal and external forces produces distinct patterns across the earth's surface that can be recognized as physical regions.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- relate landforms and their cycle of development to the theory of uniformitarianism
- demonstrate an understanding of the life history of landforms by giving examples of youthful, mature, old age and rejuvenated landforms
- illustrate, describe and cite examples of the principle types of landforms including drainage patterns, plains, plateaus, and mountains.

- Mountains are generally related belts of present or previous tectonic activity. The remaining parts of the world are generally plains, plateaus, or eroded mountains.

Learning Activities

Prior to viewing this segment, students should be acquainted with the following terms: landform, youth, maturity, old age, rejuvenation, mountain, plateau, plains.

Have students prepare a display illustrating the principle physiographic regions in the United States and their locations.

Have students prepare bulletin board displays depicting national parks and monuments created to protect specific landforms features.

Have students give reports describing a particular area of the country such as the Colorado Plateau or the Ridge and Valley Province of Virginia.

Have students prepare a display illustrating the principal differences between the Blue Ridge, Piedmont, and Atlantic Coastal Plain Province.

Invite individuals who have lived in other regions of the United States to visit the class and describe the area's climate and character.

Take students on a field trip to California and the Rocky Mountains while staying in your classroom using the FIELD TRIP KIT: ROCKY MOUNTAINS and the FIELD TRIP KIT: CALIFORNIA MOUNTAINS, both produced by Hubbard Scientific Company, Northbrook, Illinois.

Have students conduct investigations with Ward's GRAND CANYON RELIEF MODEL KIT, produced by Ward's Natural Science Establishment, Inc., Rochester, New York.

Media Resources

FILMS

COLORADO'S MAGIC WONDERLANDS. 16mm. 17 min. sd. color. Colorado State Division of Commerce and Development.

GEOGRAPHY OF THE UNITED STATES SERIES. 6 reels. 16mm. sd. color. BFA Educational Media.

IDAHO HIGH COUNTRY. 16mm. 14 min. sd. color. Idaho Dept. of Commerce and Development.

MONUMENTS TO EROSION. 16mm. 11 min. sd. color. Ency. Britannica Ed. Corp.

MOUNTAINS. 16mm. 9 min. sd. color. Indiana Univ. Audio-Visual Center, 1967.

MOUNTAINS, PLAINS, PLATEAUS. 16mm. 13 min. sd. color. Universal Education and Visual Arts, 1971.

PLAINS AND PLATEAUS. 16mm. 10 min. sd. color. Indiana Univ. Audio-Visual Center.

TOMORROW IS MAYBE. 16mm. 20 min. sd. color. Indiana Univ. Audio-Visual Center, 1971.

WYOMING - INVESTMENT IN THE GREAT OUTDOORS. 16mm. 27 1/2 min. sd. color. Wyoming Travel Commission.

FILM LOOPS

GEOLOGY LANDFORMS SERIES. 10 color film loops. Hubbard Scientific Co.

SLIDES

LANDFORMS I AND II. 2 sets, 20 color slides each.

WHAT ON EARTH? SLIDE SET G/28/1.

MODELS

LANDFORM MODELS. 8 separate raised relief maps form one 3' x 8' model. Hubbard Scientific Co.

COMPARATIVE TERRAIN MODELS. 2 models, each 18" x 24". Hubbard Scientific Co.

Teacher References

American Association of Petroleum Geologists, 1973. *United States Geological Highway Map Series.* Tulsa: American Association of Petroleum Geologists. (a series of regional maps)

Fenneman, N. M. 1931. *Physiography of the Western United States.* New York: McGraw-Hill Book Co.

__________. 1938. *Physiography of the Eastern United States.* New York: McGraw-Hill Book Co.

Raisz, Erwin. 1957. *Landforms of the United States.* (map)

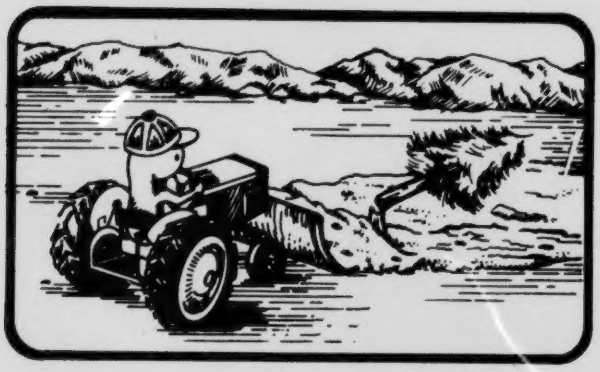
Richason, B. F. 1972. *Atlas of Cultural Features.* Chicago: Rand McNally and Co.

Shepard, F. P., and Wanless, Harold R. 1971. *Our Changing Coastlines.* New York: McGraw-Hill Book Co.

Strahler, Arthur N., and Strahler, Alan H. 1973. *Environmental Geoscience: Interaction Between Natural Systems and Man.* New York: John Wiley and Sons, Inc.

Note: See the NATIONAL GEOGRAPHIC magazine for articles on specific regions.

Man vs. the Land



Segment Synopsis

MAN VS. THE LAND poses a question for students about their life styles. The segment opens by explaining the difference between pioneer and climax species in the plant community. It then poses the question: "Is Man a Pioneer?" Examples are shown of early pioneer behavior using film of western mining towns. The Indian culture in Chaco Canyon, New Mexico, is presented to illustrate the idea that misuse and overuse of resources are not new problems. The Chaco Indians's expansion activities and their eventual consequences are explored and a case is built against overuse of the land. The segment closes by suggesting that the planet's resource problems are much more serious than the Chaco's because man has no more space in which to move.

Concepts

- Man interacts with the environment causing changes to occur that may be beneficial or detrimental to his future existence.
- Living communities follow a cycle culminating in a climax community that operates in harmony with the land.
- Man is acting as a pioneer species. The changes man is producing may make it impossible for him to live comfortably on the planet in the future.

Objectives

After watching this segment and completing appropriate follow-up activities, the student should be able to

- explain and illustrate the difference between pioneer and climax communities
- give examples of ways in which man is behaving as a pioneer species at present as well as in the past
- suggest how man might change his behavior towards a climax type relationship with the land.

Learning Activities

Prior to viewing this segment students should be acquainted with the following terms: pioneer community, climax community.

Have students read about Western Indian cultures and try to find out why they changed their life styles in the last two centuries.

Debate one of these topics:

1. Is modern man a pioneer?
2. Man's future on our planet
3. Land use planning--good or bad?

Media Resources

FILMS

COLORADO'S MYSTERY MESA. 16mm. 14 min. sd. color. Colorado State Division of Commerce and Development.

LEARNING ABOUT THE PAST. 16mm. 10 min. sd. color. Indiana Univ. of Audio-visual Center, 1951. (a title in the Prehistory Series)

MULTIPLY...AND SUBDUE THE EARTH. 16mm. 67 min. sd. color. Indiana Univ. Audio-Visual Center, 1969.

BULLDOZED AMERICA. 16mm. 25 min. sd. color. Michigan Dept. of Natural Resources.

SLIDES

WHAT ON EARTH? SLIDE SET G/28/2.

Teacher References

Hall, Stephen A. 1977. Later quarternary sedimentation and paleoecologic history of Chaco Canyon, New Mexico. *Geological Society of American Bulletin 88:* 1593-1618.

Judd, Neil M. 1922. The Pueblo Bonito expedition of the National Geographic Society. *National Geographic* 41 (March): 323-331.

Judd, Neil M. 1923. Pueblo Bonito, the ancient. *National Geographic* 48(Sept.): 227-262.

National Park Service. 1973. *Pueblo Bonito*. Globe, AZ: Southwest Parks and Monuments Association. (pamphlet)

Vivian, Gordon, and Reiter, Paul. 1965. *The Great Kivas of Chaco Canyon and Their Relationships*. Monograph No. 22. Sante Fe: The School of American Research.

29

Geologic Time

Geologic Time

Program Overview

This single segment program introduces students to the concept of geologic time, methods used for determining relative and absolute sequences of events, and the structure of the geologic timetable.

Textbook References

- A SEARCH FOR UNDERSTANDING
  - Ch. 13: Geologic Time, pp. 400-448
- MODERN EARTH SCIENCE
  - Ch. 18: The Rock Record, pp. 376 395
  - Ch. 19: The Building of a Continent, pp. 396-415
- PATTERNS IN OUR ENVIRONMENT
  - Ch. 3: Parts 13 through 24, pp. 64-77
- THE WORLD WE LIVE IN
  - Ch. 23: The Rock Record, pp. 324-338
  - Ch. 24: Precambrian Through Paleozoic, pp. 339-353
  - Ch. 25: Mesozoic Through Cenozoic, pp. 354-370
- EARTH SCIENCE: A LABORATORY APPROACH
  - Ch. 13: Time and the Earth, pp. 289-307
- EARTH SCIENCE: IIS
  - Idea 1: It's Going to Take Some Time, pp. 31-34
- FOCUS ON EARTH SCIENCE
  - Ch. 20: Dating Geologic Time, pp. 392-412
  - Ch. 21: The Geologic Time Scale, pp. 413-441.
- HOLT: EARTH SCIENCE
  - Ch. 4: Earth History, pp. 97-130
- INVESTIGATING THE EARTH
  - Ch. 15: Measuring Time, pp. 323-342
  - Ch. 16: The Record in the Rocks, pp. 343-362
  - Ch. 17: Life: Present, Past, and Future, pp. 365-391
  - Ch. 18: Development of a Continent, pp. 395-412
- OUR ENVIRONMENT IN SPACE
  - Ch. 24: Energy Systems Throughout Geologic Time, pp. 509-528
- PATHWAYS IN SCIENCE
  - III Ch. 4: The Age of the Earth, pp. 154-158

Student Readings

GEOLOGIC TIME

Newman, William L. *Geologic Time.* Washington, DC: U. S. Geological Survey, 1976. (pamphlet)

U. S. Geological Survey. *Tree Rings: Time Keepers of the Past.* Washington, DC: U. S. Government Printing Office, 1973. (pamphlet)

GEOLOGIC HISTORY

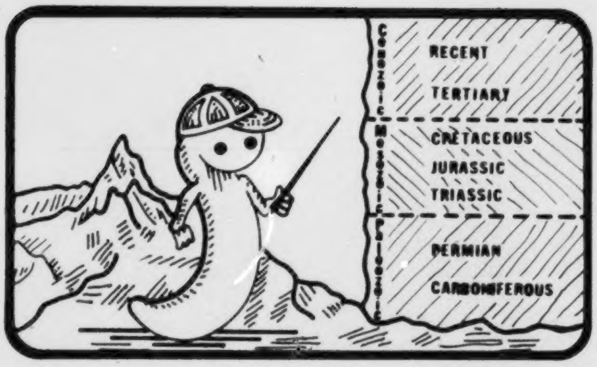
Dineley, David. *Earth's Voyage Through Time.* New York: Alfred Knopf, Inc., 1974.

Knight, Charles R. "Parade of Life Through the Ages." *National Geographic,* Feb. 1942, pp. 141-184

National Geographic Book Service. *Our Continent: A Natural History of North America.* Washington, DC: National Geographic Society, 1976.

Vitaliano, Dorothy B. *Legends of the Earth: Their Geologic Origins.* Bloomington: Indiana Univ. Press, 1973.

29-1



Geologic Time

Segment Synopsis

This final program in the WHAT ON EARTH? series considers geologic time. The program begins with a brief review of man's thinking about the age of the earth and the way the earth has changed. It presents rules for ordering events in a relative sense, using examples in nature of superpositions, unconformities, and event sequences. The history of the time scale is described, followed by an explanation of the scale's division into eras, periods and epochs. It reviews early attempts to place absolute dates on geologic events and explains the problems involved in each. During a visit to the radiometric laboratory at the University of North Carolina in Chapel Hill, radioactive decay is explored as a method for dating rocks. The program concludes with a walk through the earth's history using a football field as a scale. Major events are indicated along the scale, culminating with the Ice Age and Civilization at the goal line.

Concepts

- Natural processes acting today are the same as those which have been acting through the ages.
- Time is measured by means of events. It can be dealt with in a relative or a measured sense.
- Geologic time is subdivided largely on the basis of the evolution of life and on the amount and type of crustal activity which occurred at various times in the past.
- The natural decay of certain radioactive isotopes can be used to determine the age of rocks in years.
- The structure, texture, and composition of rocks reflect their origin and history.

Objectives

After watching this program and completing appropriate follow-up activities, the student should be able to

- relate geologic time and the principles underlying its use to the theory of uniformitarianism
- explain the differences between conventional and geologic time
- demonstrate the principles underlying radioactive dating
- develop a logical sequence of events from a geologic cross-section using the principles of stratigraphy, fossil correlation, and radioactive dating

- In an undisturbed sequence of rock layers, the oldest layers are at the bottom and the youngest at the top.
- Reconstruction of earth history from records in rocks is dependent on accurate correlation of rock units from one area to another.
- The sequence of events leading to the formation of a given rock unit is inferred on the basis of the spatial relationship of the unit to other rock units in the area.
- Fossils commonly reflect past environments and provide a means for determining a sequence of events.
- demonstrate an overall knowledge of the geologic timetable in terms of its origin, organization, and application for interpreting earth history.

Learning Activities

Prior to viewing the programs, students should be acquainted with the following terms: absolute time, relative time, radioactive decay, era, period, epoch, stratigraphy.

Have students read about James Hutton, Charles Lyell, William Smith, Abraham Wegener, and other scientists involved in developing the geologic timetable and dating techniques.

Have students conduct the following investigations from Chapter 16 "The Record in the Rocks" in Miles F. Harris's. et. al TEACHER'S GUIDE, for the Earth Science Curriculum Project textbook, INVESTIGATING THE EARTH (1973), published by Houghton Mifflin Company, Boston, Massachusetts:

16-5	Investigating Puzzles in the Earth's Crust
16-6	Correlating Rock Layers
16-7	Outcrops Reveal a Sequence of Events
16-8	Interpreting a Chapter in Earth History

Have students prepare a display showing the origin of the period on the Geologic Time Scale.

Media Resources

FILMS

THE EARTH: DISCOVERING ITS HISTORY. 16mm. 14 1/2 min. sd. color. Coronet Institute Media.

EARTH SCIENCE: PARADE OF ANCIENT LIFE. 16mm. 15 min. sd. color. Indiana Univ. Audio-Visual Center.

IN THE BEGINNING. 16mm. 28 min. sd. color. U. S. Geologic Survey, 1954.

REFLECTIONS ON TIME. 16mm. 22 min. sd. color. Ency. Britannica Ed. Corp.

THIS LAND. 16mm. 39 min. sd. color. Shell Film Library, 1973.

TIME LIFE. 16mm. 10 1/4 min. sd. color. Film Fair.

THE TREE THAT PUT THE CLOCK BACK. 16mm. 10 min. sd. color. Time-Life Films, 1971.

SLIDES

WHAT ON EARTH? SLIDE SET G/29.

STUDY PRINTS

HISTORY OF THE EARTH. 5 sets, each contains six 18" x 13" color prints. Ward's Natural Science Establishment, Inc.

TRANSPARENCIES

GEOLOGIC TIME, PARTS I AND II. 2 color transparencies. Hubbard Scientific Co.

KIT

GEOLOGIC HISTORY KIT. Ward's Natural Science Establishment, Inc.

MODEL

EARTH HISTORY MODEL. 18' x 24" model. 20 reproduction fossils. Hubbard Scientific Co.

Teacher References

Berkstresser, Charles F., Jr. 1977. History of geologic system--period terms. *California Geology* 30 (11): 259-261.

Berry, William. 1969. *Growth of a Prehistoric Time Scale*. San Francisco: W. H. Freeman and Co.

Castillo, Raymond A., and Ward, Roger W. 1968. Half-life analog using sugar cubes. *The Science Teacher* 35 (7): 83-84.

Cloud, Preston, ed. 1970. *Adventures in Earth History*. San Francisco: W. H. Freeman and Co.

Dunbar, Carl O., and Waage, Karl M. 1969. *Historical Geology*. 3rd ed. New York: John Wiley and Sons, Inc.

Editors. 1978. How much is a million? *Science and Children* 15 (Feb.): 6.

Eicher, Don L. 1976. *Geologic Time*. 2nd ed. New York: Prentice-Hall, Inc.

Fenton, Carroll Lane, and Fenton, Mildred Adams. 1952. *Giants of Geology*. rev. ed. Garden City, NY: Doubleday and Co., Inc.

Guthrie, Russell D. 1972. Recreating a vanishing world. *National Geographic* 141 (March): 294-301.

Hurley, Patrick M. 1959. *How Old is the Earth*. Garden City, NY: Doubleday and Co., Inc.

Richards, L. W., and Richards, G. L., Jr. 1962. *Geologic History at a Glance*. Stanford: Stanford Univ. Press. (three posters)

Seyfert, Carl K., and Sirkin, Leslie A. 1973. *Earth History and Plate Tectonics: An Introduction to Historical Geology*. New York: Harper and Row.

Zahl, Paul A. 1977. Amber: golden window on the past. *National Geographic* 152 (Sept.): 423-435.

Equipment for the Earth Science Classroom

The equipping of an earth science classroom/laboratory is an expensive and involved procedure. The specific items which should be in any given school depend on its location, physical plant, and student population. Ideally, the terrain surrounding a school should include a stream along with various types of terrain and ground cover. In reality, few schools have all these features and as a result the kinds of student activities that may be carried out vary widely. This equipment list assumes that the school's media center supplies overhead, slide, and motion picture projectors; television monitors; videocassette recorders and all types of media on a check out basis. It also assumes that the media center had acquired or is acquiring an appropriate collection of slides, transparencies, and books appropriate to the earth sciences.

The equipment itemized on this list is intended to be kept in the classroom on a permanent basis. No effort has been made to indicate the order in which items should be acquired as that must be determined by the school setting and program. Every effort has been made to make the list complete but some commonly used items were omitted from the "supplies" list because they are normally available in nearly every school.

Equipment

1. Anemometer - combined wind speed and direction indicator--electric - for roof mounting, batteries in most units will last at least one year
2. Acceleration kit - for study of falling objects
3. Aprons - plastic, student
4. Atomic model kits - should contain sufficient atom centers and bonds to construct structure models for each of the six basic crystal systems
5. Balances - platform - should be adaptable for determining specific gravity and spring
6. Barometer - Aneroid - while mercury barometer are desirable, the dangers of metallic mercury rules out its use in the classroom
7. Basketball or Volleyball - for use as simulated planet
8. Beakers - assorted sizes of pyrex and polyethelene
9. Bottles and jars - assorted sizes including: 1 quart (liter) sample containers, 1 gallon jugs for cloud formation demonstration, acid bottles with droppers for mineral and rock identification labs
10. Buckets - 1 gallon plastic for use in sampling streams, ponds, oceans, etc.
11. Bunsen Burners - or propane torches

12. Cans - shiny aluminum and black-fitted with insulation for absorption investigations

13. Clamps and Tongs of various types - condenser, test tube, beaker, crucible, hose clamp, both pinch and screw type

14. Clock - wall model with second hand - preferably clock should be equipped with a switch for stopping and starting the unit

15. Compasses - Magnetic-equipped for declination compensation

16. Compasses - Brunton Cadet-for geologic-mapping equipped to measure strike and dip

17. Convection Chambers for-demonstrating vortex formation in tornadoes

18. Transparent Crystal Models-for use in demonstrating crystal symmetry

19. Crucibles

20. Eye Wash Station- OSHA approved type

21. Fan - electric or blower - for use in wave generation

22. Fire Blanket

23. Fire Extinguishers - approved type

24. First-aid cabinet with supplies

25. Flashlight - preferably 6 volt unit

26. Flashlight - bulb and socket with battery source-for use in globe projector.

27. Flasks - Florence - flat bottom-Pyrex or Polyethelene, assorted sizes

28. Flasks - Florence - round bottom, 3,000 ml. for use in globe projector

29. Fossils - 1 set of fossil specimens should be maintained for demonstration purposes including the following:

    1 Trilobite
    1 Brachipod
    1 Cephalopod
    1 Gastropod
    1 Vertebrae (porpoise or fish)
    1 Shark tooth
    1 plant in shale (preferably fern) showing leaves
    1 piece of petrified wood showing structure
    1 worm trails on tubes in sandstone or shale
    1 cast or mold of any of the above
    1 slab of coral bryozoan or crinoid material

    Kits or sets of fossils for students' use may be assembled in areas where fossils are abundant. In other areas you may wish to purchase plastic replicas available from equipment supply firms.

30. Fossil models - vertebrate skeletons, plastic to be used in paleontology exercises (available through hobby stores)

31. Funnels - short and long stem

32. Foam rubber - flexible (approximately 18 x 4 x 1½) in different colors for use in demonstrating folds

33. Gauge - Rain - large scale plastic or metal to be used to demonstrate multiplier effect as applied to gauging precipitation.

34. Globes - Political
    Physiographic showing features of ocean floor
    Chalk - markable

35. Goggles - student (OSHA approved with cabinet)

36. Graduated cylinders - unbreakable (assorted sizes)

37. Hand tools with Box - including hammer, screw driver, pliers, tin snips, etc.

38. Hammers - Geologic (one per class)

39. Hand lenses: 1. (10 x with case) for use in study of rocks (1 case to each 2 students) 2. (B & L Coddington 10 x for teacher use)

40. Hot Plate - Electric

41. Magdeburg hemispheres - or pair of "plumbers helpers"

42. Magnets - Bar

43. Maps

1 set for each five students	A set of 25 topographic maps illustrating specified physiographic features. U. S. Geologic Survey.	This set can be developed into a number of laboratory activities that allow students to study important landforms and the result of tectonic or erosional processes using real examples.
1 for each 2 students	A topographic map of the area in which your school is located. (Preferably 7½' size) U. S. Geologic Survey.	Maps of your local area are the best teaching tools for map reading.
1 each	Maps of various types: A. Geologic map of North America 1:5,000,000 U.S.G.S. B. Chesapeake Bay sheet (NJ-18) of the International Map of the world. U.S.G.S. Also: Hatteras sheet (NI-18) Lookout Mountain sheet (NI-16) C. Plastic Relief Maps - (Scale 1:250,000) Appalachians, world, United States	Students need an opportunity to study various types of maps first hand. The larger types can also be wall-mounted adding to the color and character of the classroom.

D. North Carolina - Political - U.S.G.S.
   (State 1:500,000) Topographic--U.S.G.S.
   Relief--U.S.G.S.
   Roads--free Highway Department
E. Oceanographic Charts
F. North Carolina Soils Map
G. Satellite Photos
H. Status of Mapping indexes (current)--topographic
   aerial photography
I. Weather Map (markable with chalk)--United States
J. Physiographic--Maps of world (National Geographic Society)
   --Maps of United States
   --Maps of ocean basins (National Geographic Society)

44. Metersticks

45. Microprojector - bioscope

46. Minerals - 1 set for teacher use consisting of 5" x 6" mineral specimens
    1 set for every two students consisting of 1" x 2" mineral specimens

Preferred Minerals

Quartz
Orthoclose Feldspar
Plagioslase Feldspar
Muscovite Mica
Biotite Mica
Amphibole
Pyroxene
Olivine
Chlorite
Garnet
Calcite or Dolomite
Magnetite or Hematite
Gypsum
Pyrite

The majority of these minerals can be collected from currently operating mines or old mine dumps.

47. Models:

Map Projection Model - consisting of cylindrical, conical and azimuthal projections on plastic sheets along with a matching globe.

Weather Model - three dimensional model showing cold and warm fronts about low pressure center

Stream table - water proof tray approximately 60 x 20 x 6 with a water source and sand to be used for simulation of stream and shoreline features. Unit should be equipped with wave generator and sprinkler unit for rain simulation.

Sedimentation Tanks - tank with transparent sides approximately 48" x 12" x 2" to be used for study of wave motion, sedimentation, beach and delta building, and turbidity currents.

Landform Models (optional) - plastic units illustrating the landforms that result from the erosion of various geologic structures. Sides of models should show geologic structure.

Erosion Models - models illustrating the results of erosional forces such as glaciers

48. Oceanography - If your school is located near a large body of water (pond, lake or ocean) that would make the study of water related phenomena possible, you should consider adding the following instruments to this list. Most of this equipment can be constructed inexpensively from locally available materials.

    A. Seechi disk
    B. Nisken bottle
    C. Bottom Grab sampler
    D. Plankton net
    E. Water chemistry kit

49. Pans - flat

50. Pans - with high sides

51. Pendulum demonstration apparatus - may be constructed as a permanent part of the classroom

52. Permeability columns - set of 4 or 5 - consists of clear plastic tubes, 2 cm in diameter, and one meter long. Tubes should be fitted with a screen and cap on one end. The sealed end should be drainable by means of a rubber tube controlled with a spring clamp.

53. Pipe steel 1¼" x 4"

54. Psychrometer - sling variety with protected thermometers.

55. Ring stands with assorted rings and clamps

56. Rock specimens:

1 set for teacher use consisting of 5" x 6" specimens
1 set for every two students consisting of 1" x 2" specimens

Preferred Rock Specimens

Sedimentary	Igneous	Metamorphic
Sandstone	Granite	Phyllite
Shale	Diorite	Schist
Limestone (massive)	Gabbro	Gneiss
Limestone (fragmental)	Basalt	
Conglomerate	Pumice	
Coquina	Scorria	
	Rhyollite	
	Obsidian	

(Note: Most of the rock types listed above can be collected in operating quarries or monument works.)

57. Rolling Pins - or short pieces of broomstick

58. Rods - Stadia - for use in constructing topographic maps. These rods can be constructed from 1" x 4" boards 10 ft. long and painted appropriately.

59. Rotating Laboratory stool or piano stool.

60. Scale - bathroom type

61. Screen Sieves set - used to separate soil and sediment samples, consists of 4 screen sieves of various sizes with a solid bottom and cover (1 set per class)

62. Sighting devices - for use in constructing topographic maps, may be constructed from scrap lumber and a pocket level

63. Seismograms - available from National Geophysical Data Center, Boulder, Colorado 80302

64. Shovel

65. Soil Auger

66. Spectroscope - handheld viewing variety

67. Streakplates - unglazed porcelain plates--can be acquired from local ceramic tile contractor

68. Styrofoam balls (100) with connectors to be used in mineralogy

69. Telescope - This is an expensive item and should be acquired only when all other necessary materials have been purchased.

70. Tape Measure - cloth (English--metric)
steel (English--metric)

71. Test Tubes - Pyrex--assorted sizes.

72. Thermometers, celcius - 20° to 110° (with metal guards)
Thermometers, fahrenheit 0° to 220° (with metal guards)

73. Tire Pump

74. Turntable - should be constructed of plywood and be large enough to accommodate a model pendulum

75. Triangular filles

76. Vacuum pump

77. Watch glasses

Supplies

Balloons, toy
Battery, dry-cell, low voltage
Brass paper fasteners
Bricks
Candles, assorted sizes
Cardboard

Chemicals
- Alum
- Cornstarch
- Hydrochloric acid
- Iron filings
- Limestone chips
- Phenylsclicylate
- Pyrite specimens, small
- Sulfur, powdered
- Table salt

Clay, potter's
Cloth
Coal, soft
Coat hanger, wire
Compass, drawing (teachers' chalk)
Construction paper, various colors
Corks, assorted sizes
Crepe paper
Diffraction grating, replica
Egg beater
Filter paper
Food coloring
Glass plates, approximately 3" x 3"
Glass rods, assorted diameters
Glass tubing, assorted diameters
Glass tubing, 1" in diameter by 30" in length
Glue
Graph paper
Gravel
Hardboard (Masonite) 18" x 18" x 1/4"
Ink
Protractors, teacher's demonstration and student
Razor Blades
Rulers, 12"
Rubber bands
Rubber stoppers, assorted sizes--solid, one-hole, two-hole
Rubber tubing, several diameters
Sand
Screen wire
Sewing Needles
Steel wool
Straight pins
String
Thumbtacks
Translucent paper
Wire, insulated, copper
Wire screen, 4" x 4"
Wood shavings
Vermiculite mica
Vaseline
Matches
Marbles, large and small
Modeling clay (various colors)
Paper cups
Paper towels
Pebbles
Pegboard, Masonite
Pennies (half-life laboratory)
Ping-Pong balls or balls of similiar size
Plaster of Paris
Plastic bottles, with screw caps
Plastic sheet (painter's drop cloth)
Plastic tubing
Plastic food wrap
Platinum or Nichrome wire mounted in glass handles

Textbook Bibliography

Bernstein, Leonard, and Harry K. Wong. *Earth Science: Ideas and Investigations in Science.* Englewood Cliffs, NJ: Prentice-Hall, Inc., 1977. 326p.

Bishop, Margaret S., Phyllis G. Lewis, and Richmond L. Bronaugh. *Focus on Earth Science.* 2nd ed. Columbus, OH: Charles E. Merrill Publishing Co., 1972. 564p.

Bisque, Ramon E., Harold Pratt, and John F. Thompson. *Earth Science: Patterns in Our Environment.* Englewood Cliffs, NJ: Prentice-Hall, Inc., 1975. 304p.

Brown, Walter R., and Norman D. Anderson. *Earth Science: A Search for Understanding.* Philadelphia, PA: J. B. Lippincott Company, 1973. 703p.

Harris, Miles F., et al. *Investigating the Earth.* rev. ed. Boston: Houghton Mifflin Company, 1973. 529p.

Marean, John H., et al. *Earth Science: A Laboratory Approach.* Menlo Park, CA: Addison-Wesley Publishing Company, 1970. 324p.

Namowitz, Samuel N., and Donald B. Stone. *Earth Science: The World We Live In.* 5th ed. New York: American Book Company, 1975. 678p.

Navarra, John Gabriel and Arthur M. Strahler. *Our Environment in Space: The Earth Sciences.* New York: Harper and Row, Publishers, Inc., 1973.

Oxenhorn, Joseph M. *Pathways in Science--Earth Science.* combined ed. Ed. Peter Greenleaf. New York: Globe Book Company, 1977. 514p.

Ramsey, William L., et al. *Holt: Earth Science.* New York: Holt, Rinehart and Winston, Inc., 1978. 503p.

Ramsey, William L., et al. *Modern Earth Science.* New York: Holt, Rinehart and Winston, Inc., 1973. 580p.

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Academy Films, P. O. Box 38753, Hollywood, California 90038

Addison-Wesley Publishing Company, Inc., 2725 Sand Hill Road, Menlo Park, California 94025

Aetna Life and Casualty, Public Relations and Advertising Dept., Film Library, 151 Farmington Avenue, Hartford, Connecticut 06115

American Association of Petroleum Geologists, P. O. Box 979, Tulsa, Oklahoma 74101

American Education Publications, Middletown, Connecticut

American Educational Films, 132 Lasky Drive, Beverly Hills, California 90212

American Elsevier Publishing Co., 52 Vanderbilt Avenue, New York, New York 10017

American Gas Association, Film Service Library, 1515 Wilson Boulevard, Arlington, Virginia 22209

American Geological Institute, 5205 Leesburg Pike, Falls Church, Virginia 22041

American Meteorological Society, 45 Beacon Street, Boston, Massachusetts 02108

American Petroleum Institute, 1801 K Street, N. W., Washington, D.C. 20006

Anchor Books, 501 Franklin Avenue, Garden City, New York 11530

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Astrafilms, Inc. - distributed by Environmental Educators, Inc., 732 Seventh Street, N. W., Washington, D. C. 20006

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Association - Sterling Films, 5797 New Peachtree Road, Atlanta, Georgia 30340

Audobon Magazine, 950 Third Avenue, New York, New York 10022

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Blaisdell Publishing Company, 501 Madison Avenue, New York, New York 10002

Bonneville Power Administration, U. S. Dept. of the Interior, P. O. Box 3621, Portland, Oregon 97208

Brigham Young University Press, 204 University Press Building, Provo, Utah 84602

Bulletin, American Meteorological Society, 45 Beacon Street, Boston, Massachusetts 02108

Burgess Publishing Co., 7108 Ohms Lane, Minneapolis, Minnesota 55435

California Geology, Division of Mines and Geology, 1416 9th Street, Room 1314, Sacramento, California 95814

Cambridge University Press, 32 East 57th Street, New York, New York 10022

Carolina Biological Supply Company, Burlington, North Carolina 27215

Caterpillar Tractor Company, Modern Talking Picture Service, Caterpillar Film Library, 1687 Elmhurst Road, Elk Grove Village, Illinois 60007

Chronicle Books, 870 Market Street, Suite 915, San Francisco, California 94102

Churchill Films, 662 North Robertson Boulevard, Los Angeles, California 90069

Citadel Press, Subs. of Lyle Stuart, Inc., 120 Enterprise Avenue, Secaucus, New Jersey 07094

Colorado Geological Survey, Denver, Colorado

Colorado State Division of Commerce and Development, Tourist Development Section, 602 State Capitol Annex, Colorado 80203

Colorado State University, Institute of Technical and Industrial Communications, Social Sciences Building, Room C 225, Fort Collins, Colorado 80523

Columbia University Press, 136 S. Broadcast, Irvington-on-Hudson, New York 10533

Communications Research Machines, Inc., 201 East 50th Street, New York, New York 10022

Comstock Publishing Associates, Cornell University Press, 124 Roberts Place, Ithaca, New York 14850

Conway Research, Inc., Peachtree Air Terminal, 1954 Airport Road, Atlanta, Georgia 30341

Coronet Instructional Media, 65 East South Water Street, Chicago, Illinois 60601

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Earth Science, Earth Science Publishing Company, P. O. Box 1815, Colorado Springs, Colorado 80901

Earth Science Materials, P. O. Box 2121, 1900 E. Lincoln Avenue, Fort Collins, Colorado 80522

Educational Activities, Inc., 1937 Grand Avenue, Baldwin, New York 11510

Elsevier - North Holland Publishing Company, 52 Vanderbilt Avenue, New York, New York 10017

Encyclopaedia Britannica Educational Corporation, Dept. 20A, 425 North Michigan Avenue, Chicago, Illinois 60611

Environment Magazine, P. O. Box 3066, St. Louis, Missouri 63130

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Ideal Pictures Film Library, 4931 West North Avenue, Milwaukee, Wisconsin 53208

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Indiana University Press, Tenth and Morton Streets, Bloomington, Indiana 47401

Institute of Marine Sciences, Marine Materials Centers, Virginia Institute of Marine Sciences, Gloucester, Virginia 23062

Journal of Geological Education, National Association of Geology Teachers, Box 368, Lawrence, Kansas 66044

Journal of Marine Education - see Sea World Magazine

K. C. Publications, P. O. Box 14883, Las Vegas, Nevada 89114

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Meredith, Consumer Book Division, 1716 Locust, Des Moine, Iowa 50336

Charles E. Merrill Publishing Co., 1300 Alum Creek Drive, Columbus, Ohio 43216

Julian Messner, Inc., One West 39th Street, New York, New York 10018

Michigan Dept. of Natural Resources, Film Loan Service, Lansing, Michigan 48926

Milner - Fenwick, Inc., 3800 Liberty Heights Avenue, Baltimore, Maryland 21215

Mockingbird Books, Box 624, St. Simons Island, Georgia 31522

Modern Learning Aids, P. O. Box 1712, Rochester, New York 14603

Modern Library, Inc., 201 East 50th Street, New York, New York 10022

Modern Talking Picture Service, 2323 New Hyde Park Road, New Hyde Park, New York 11040

Montana Highway Commission, Advertising Dept., Helena, Montana 59601

Moody Institute of Science, 12000 East Washington Boulevard, Whittier, California 90606

Moonlight Productions, 2650 California Street, Mountain View, California 94040

William Morrow and Co., Inc., Six Henderson Drive, West Caldwell, New Jersey 07006

C. V. Mosby Co., 11830 Westline Industrial Drive, St. Louis, Missouri 63141

NBC-TV Film, Inc., 30 Rockefeller Plaza, Room 914, New York, New York 10020

NOAA Journal, National Oceanic and Atmospheric Administration, Public Affairs Office, Rockville, Maryland 20852

National Aeronautics and Space Administration, NASA Langley Research Center, Langley Station, Public Affairs Office, Mail Stop 154, Hampton, Virginia 23365

National Climate Center, Asheville, North Carolina 28801

National Coal Association, Modern Talking Picture Service, 2323 New Hyde Park Road, New Hyde Park, New York 11040

National Geographic Society, 17th and M Streets, N. W., Washington, District of Columbia 20036

National Medical Audiovisual Center, 2111 Plaster Bridge Road, Atlanta, Georgia 30324

National Oceanic and Atmospheric Administration, U. S. Dept. of Commerce, 12231 Wilkins Avenue, Rockville, Maryland 20852

National School Weather Project, State University of New York at Brockport, Brockport, New York 14420

National Science Teachers Association, 1742 Connecticut Avenue, N. W., Washington, D. C. 20009

National Weather Digest, National Weather Association, P. O. Box 243, Clinton, Maryland 20735

National Weather Service, 8060 13th Street, Silver Springs, Maryland 20910

Thomas Nelson, Inc., 30 East 42nd Street, New York, New York 10017

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North Carolina State University, Agricultural Experiment Station, Raleigh, North Carolina 27607

W. W. Norton and Company, Inc., 500 Fifth Avenue, New York, New York 10036

Oceanus Magazine, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts

Office of Coastal Management, National Oceanic and Atmospheric Administration, 3300 Whitehaven Street, N. W., Washington, D. C. 20235

Oxford University Press, 200 Madison Avenue, New York, New York 10016

Paleontological Research Institution, 1259 Trumansburg Road, Ithaca, New York 14850

Parents Magazine Press, 52 Vanderbilt Avenue, New York, New York 10017

Peabody Museum of Natural History, Yale University, 170 Whitney Avenue, New Haven, Connecticut 06520

Pergamon Press, Inc., Maxwell House, Fairview Park, Elmsford, New York 10523

Petrified Forest Museum Association, Holbrook, Arizona

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Rocks and Minerals Magazine, Box 29, Peekskill, New York 10566

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Charles Scribner's Sons, 597 Fifth Avenue, New York, New York 10017

Sea Chest Magazine, Cape Hatteras Schools, Bolton, North Carolina 28423

Sea Frontiers Magazine, International Oceanographic Foundation, 3979 Rickenbacker Causeway
Miami, Florida 33149

Sea World Magazine, National Marine Education Association, 1250 Sixth Avenue, San Diego,
California 92101

Shell Film Library, 1433 Sadlier Circle West Drive, Indianapolis, Indiana 46239

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Smithsonian Institution Press, Room 2280, Arts and Industries Building, Washington,
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Smithsonian Magazine, 900 Jefferson Drive, N. W., Washington, D. C. 20560

Society for Visual Education, Inc., 1345 Diversey Parkway, Chicago, Illinois 60614

Society of Exploration Geophysicists, P. O. Box 3098, Tulsa, Oklahoma 74101

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Durham, North Carolina 27708

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UNC Sea Grant Publications, North Carolina State University, Raleigh, North Carolina 27607

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U. S. Army Engineer District, St. Paul, 1135 U. S. Post Office and Customhouse, St. Paul, Minnesota 55101

U. S. Army Engineer Division, South Atlantic, 510 Title Building, 30 Pryor Street, S. W., Atlanta, Georgia 30303

U. S. Army Engineer Waterways Experiment Station, Attention: WESTS, P. O. Box 631, Vicksburg, Mississippi 39180

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U. S. Dept. of Agriculture, Washington, D. C. 20250

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U. S. Geological Survey, 12201 Sunrise Valley Drive, Reston, Virginia 22092

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U. S. Naval Oceanographic Office - see U. S. Navy

U. S. Navy, Naval Education and Training Support Center, Atlantic Naval Station, Building Z-86, Norfolk, Virginia 23511

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Weatherwise Magazine, Helen Dwight Reid Educational Foundation, Editorial and
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Worldwide Research and Publishing Company, National Parks Division, 12124 West 30th,
Casper, Wyoming 82601

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